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Report No. CG-D-65-76

HYDROSTATICS AND EQUILIBRIUM CHARACTERISTICS COMPUTER PROGRAM FOR RECREATIONAL BOATS

Peter Secrest

U. S. Coast Guard Research and Development Center
Avery Point
Groton, Connecticut 06340

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Final Report

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DEPARTMENT OF TRANSPORTATION
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<u>**N O T I C E**</u>

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16. Abstract

This report is intended to serve as complete documentation of a versatile computer program which calculates hydrostatics and equilibrium characteristics. It differs from other hydrostatics programs in its applicability to odd-shaped boats and in its capability of performing equilibrium calculations.

The integration scheme uses trapezoidal rule throughout, allowing random spacing of points and stations defining the hull form. This allows almost every type of hull form to be represented and computations performed.

The equilibrium characteristics feature allows determination of transverse and longitudinal righting moment curves, heave restoring forces, trim vs. heel angle coupling, etc. It also is possible to determine the draft, trim and heel for any loading condition.

Included in the report are a program explanation, user guide, program listings, program flow charts, and a sample run.

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METRIC CONVERSION FACTORS

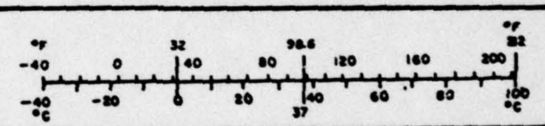
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 PROGRAM CHARACTERISTICS OVERVIEW

This report is intended to serve as complete documentation of a versatile computer program which calculates hydrostatics and equilibrium characteristics. Its chief differences from other hydrostatics programs are applicability to odd-shaped boats and capability of performing equilibrium calculations.

What makes this program applicable to odd-shaped boats? The integration scheme utilizes trapezoidal rule throughout, which allows the points defining the hull to be spaced at completely random intervals, with closer spacing in regions of greatest curvature. The transverse sections through the hull can also be spaced at random intervals. With this method of hull definition, virtually every type of hull form--including conventional ship shape hulls, boats with hard chines, cathedral hulls, stepped planing boats and catamarans--can be represented and computations performed.

The equilibrium characteristics feature allows determination of transverse and longitudinal righting moment curves, heave restoring forces, trim vs. heel angle coupling, heave vs. heel angle coupling, trim vs. heave coupling, etc. It also makes it possible to determine the draft, trim and heel for any loading condition.

This computer program was developed as a tool for use in recreational boating safety research. Certain characteristics of recreational boats made a computer program of this type desirable. These characteristics of recreational boats are:

a. The hull shape of recreational boats (hard chines, cathedral hull forms, etc.) precludes usage of Simpson's Rule integration or any other parabolic method.

b. The low length-to-beam ratio of recreational boats causes considerable coupling between restoring forces. A righting arm curve which held pitch and draft constant while varying the heel angle would have little meaning for this type of boat.

c. For boating safety research a program was needed which would give equilibrium characteristics for a given load condition so that the effect of various loading configurations could be examined.

A general comment should be made regarding the errors inherent in representing a hull shape by a series of offsets. If too few offsets are taken to define the hull form, errors may be large; while if too many are taken, the time spent in preparing the data is excessive. The "trapezoidal rule" employed for integration in this program has no error by itself--any error comes from inadequacy of hull representation. The overall error depends primarily on the "engineering judgment" of the user in preparation of the offsets, and the only true test of whether sufficient offsets have been used is comparison with full-scale results for the particular boat in question. As an example a sample run has

been included in Appendix C of this report. For the equilibrium case, results were within the accuracy of fullscale measurements of actual draft, trim and heel.

The program and subroutines developed are written in FORTRAN V language and are intended for batch processing use. Section 2.0 of this report describes the various sections of the computer program and the subroutines. Section 3.0 provides usage instructions. Section 4.0 explains the output from the program, and Section 5.0 explains program error messages. Included in the appendices are listings and flow charts of the program elements, definitions of program variables, a sample run, and test results used for program verification.

2.0 PROGRAM DESCRIPTION

The main element of this program performs the input and output and most of the calculations with the exception of the integrations. Figure 1 shows a block diagram of the program. The functions of the various modules shown are explained in the following sections.

Three subroutines are used to handle the integration. Subroutine SECT performs integration over one station; subroutine ENDPT determines the fore and aft end points of the underbody; and subroutine INTEG integrates over the length of the hull (between the two end points). These subroutines are discussed in Sections 2.10, 2.11 and 2.12 respectively.

2.1 Section for Input and Output of Hull Form Data

Input and output device numbers are defined at the beginning of the program. These must be changed for each computer system. This section reads in data which defines the number of stations, station numbers, and at each station the number of offsets, the longitudinal position, and the half-breadth and height at each point. The format of the data cards is given in Section 3.3. In this section all the input data is also printed out to allow a check of the input data.

2.2 Section for Input of Case Data

In this section the number of cases to be examined is read into the program. The program then begins a DO LOOP in which it reads in data for one case and then does the calculations for that case before reading in the data for the next case. Within this section, the data for one case is read in. The data read in is weight of the craft, LCG, TCG and VCG (longitudinal, transverse and vertical centers of gravity) of the craft, draft, trim angle, heel angle, water density and three control codes which control the equilibrium process. The format of these data cards is given in Section 3.3. Further explanation of the case data is provided in Section 3.2.

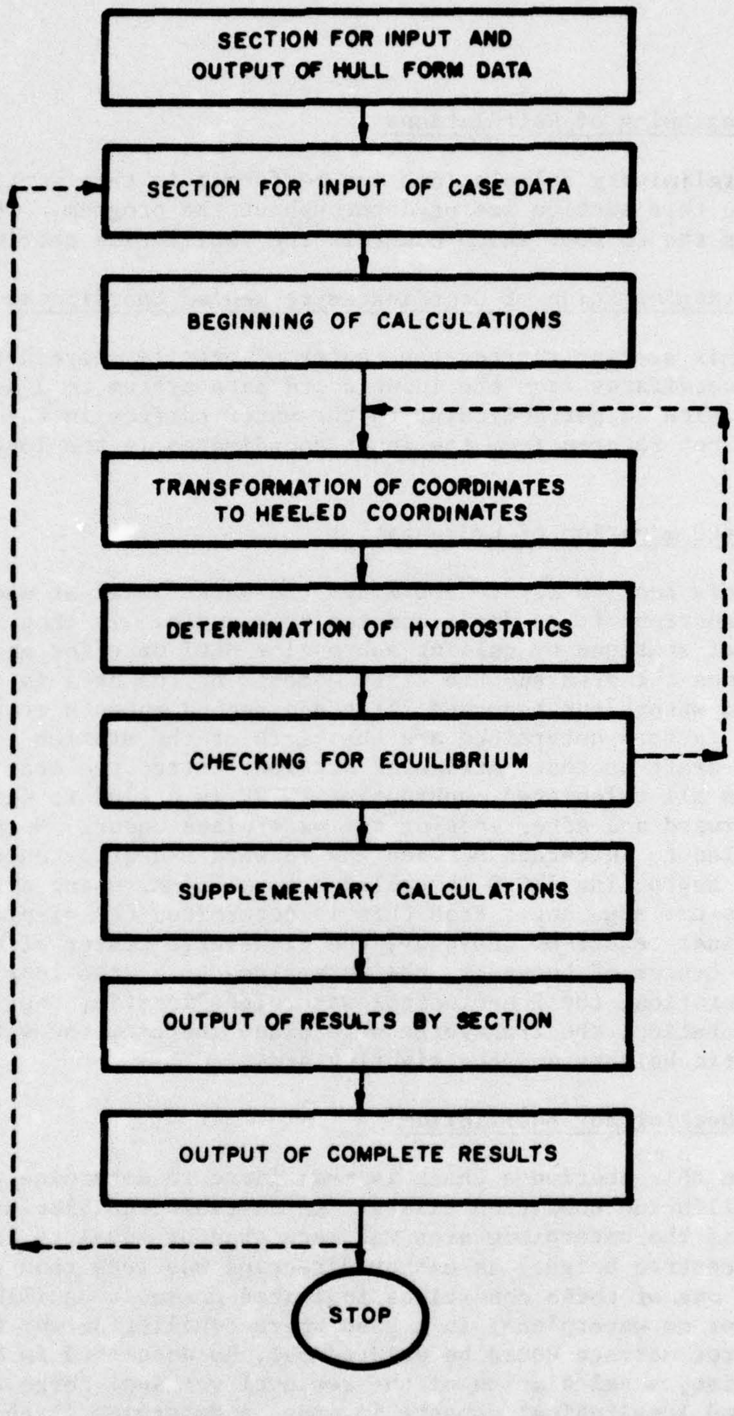


FIGURE 1. BLOCK DIAGRAM OF PROGRAM

2.3 Beginning of Calculations

Preliminary calculations are performed in this section. Variables calculated in this section are used throughout the program. This section also includes the DO LOOP which controls the equilibrium seeking process.

2.4 Transformation of Coordinates to Heeled Coordinates

This section rotates the center of gravity coordinates and the offset coordinates from the input coordinate system to a heeled coordinate system which is perpendicular to the water surface in the transverse plane but is not rotated from the input coordinates in the longitudinal plane.

2.5 Determination of Hydrostatics

This section first determines the water level at each station, which is a function of the draft and the trim angle. It then integrates the individual stations by calling subroutine SECT once for each station. This determines the area and the first moments of the area in two directions and the waterplane beam and first and second moments of the waterplane beam. Other factors determined are the girth of the station to the waterline and the draft at that particular station. After the station characteristics are all calculated, subroutine ENDPT is called to determine where the forward and after ends of the waterplane occur. Next subroutine INTEG is called to integrate between the forward and after ends of the waterplane. Subroutine INTEG is called several times using different parameters as the argument. From this is determined the displaced volume, the longitudinal center of buoyancy, the transverse center of buoyancy, the vertical center of buoyancy, the waterplane area, the longitudinal center of flotation, the longitudinal waterplane inertia, the transverse center of flotation, the transverse waterplane inertia, the wetted surface, the metacentric heights and the righting arms.

2.6 Checking for Equilibrium

In this section a check is made first to determine whether an unstable equilibrium condition exists. An unstable equilibrium condition would exist if the waterplane area was less than or equal to zero or the $\overline{GM}$ (metacentric height) in either direction was less than or equal to zero. If one of these conditions indicated unstable equilibrium (i.e., negative $\overline{GM}$ or no waterplane) in a case where equilibrium was being investigated, an error message would be printed out, as described in Section 5.0. Otherwise, a calculation of the residual vertical force and residual transverse and longitudinal moments is made to determine if these are within predefined error limits. If the three parameters are outside the error limits, then new calculations of the draft, trim and heel are made, and the sequence is repeated for those new conditions. If, however, the three parameters are within the error limits, equilibrium has been achieved and the program moves on to the supplementary calculations. After 99 iterations, if equilibrium has not yet been achieved, a warning message is printed out, as explained in Section 5.0.

2.7 Supplementary Calculations

This section determines parameters that are based upon those calculated in the previous section. Parameters which are calculated here are the maximum section area, the maximum draft, the maximum beam, centers of buoyancy and flotation, coefficients relating the hull volume and waterplane area to overall dimensions, and residual vertical forces and righting moments. The centers are then rotated back to the original coordinate system.

2.8 Output of Results by Section

This section prints out a table of results by section in the format shown in Section 4.0. The information included in this table is all of the information calculated for each station. At the end of the table, the case data which was used is printed out in the same format in which it was read from the data card.

2.9 Output of Complete Results

The output from this section constitutes the second page of the output for each case. This is a compact table which presents for each case the input data, the calculated displacement, centers of buoyancy, centers of flotation, waterplane area, residual moments and forces, coefficients, stability characteristics, and maximum dimensions of the underwater hull shape. This output is further described in Section 4.0.

2.10 Subroutine SECT for Calculating Section Characteristics

This subroutine takes the offsets for one station and integrates them between specified limits. First and second moments are taken using trapezoidal rule. Values calculated in this subroutine include section area, section beam, section waterplane beam, transverse and vertical moments of the area, transverse first and second moments of the waterplane beam, and girth of the underwater sections.

Subroutine SECT performs the integration by dividing the submerged section up into vertical, trapezoidal shaped strips, each defined by two consecutive offsets. The area of each strip is then found, along with the moment of that area about the centerline and waterline. By summing up all the strips, the area and center of the station are determined. At the same time as performing this integration, the subroutine also determines the width of the waterplane at the station, which allows the characteristics of the waterplane (area, center and inertia) to be determined as well.

2.11 Subroutine ENDPT for Calculating End Points of Waterplane

This subroutine takes as input the drafts calculated at each station and determines where the forward and after ends of the waterplane are by determining where the drafts change from positive to negative and performing a linear interpolation to identify the crossing point.

2.12 Subroutine INTEG for Integrating Over Length of Hull

This subroutine takes as input X and Y arrays, where the X-array is the longitudinal location and the Y-array is the parameter to be integrated, and the end points of the waterplane defined previously. The subroutine then performs a trapezoidal integration along the X axis between the two end points to determine the area and the first and second moments of that area for the parameter being integrated.

Subroutine INTEG performs the integration by dividing the curve (such as a "section area curve") up into trapezoidal-shaped strips, with each strip extending from one station to the next. The area of each strip, along with the first and second moment of that area about amidships, is then found. By summing all the strips, the area under the curve (and the associated first and second moments of the curve) is determined.

3.0 USAGE INSTRUCTIONS

The following sections present the information needed to run the computer program in its many different forms.

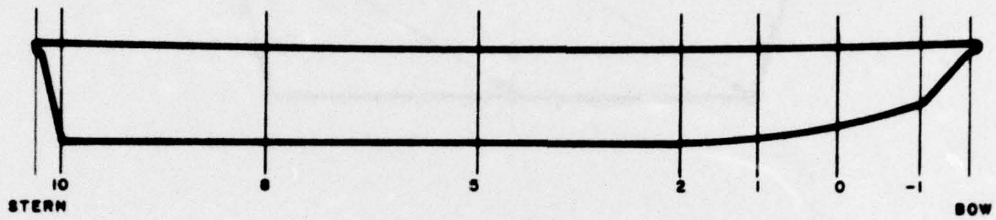
3.1 Hull Form Description

The axis system used to describe the hull form is a right-handed Cartesian coordinate system with the center of the system located at amidships on the centerline of the boat at the keel. X is positive forward; Y is positive to port; and Z is positive upwards. Angular displacements follow the standard sign convention used on right-handed coordinates.

The hull is defined by an arbitrary number of sections through the hull in the Y-Z plane. These stations may be located at arbitrary spacing to provide the best hull definition in areas of high curvature. Figure 2 shows station locations defining two typical hull forms. Station numbers or names are also arbitrary and bear no relation to the axis system. A station with zero area may be used at the bow and at the stern, if desired, to allow integration to continue out to the true end of the boat. The program is currently dimensioned to accept up to 25 stations.

Each station is defined by an arbitrary number of points located at arbitrary spacing around the section. The station is assumed to be symmetrical about the centerline. This assumption of symmetry is for convenience in input of hull form data only--if the input section were changed, non-symmetrical hulls could be accommodated. Y and Z coordinates define the shape of one side of the station, and the program creates offsets for the other side of the station. The points for each station are entered in order, as shown in Sections 3.3 and 3.4, with the first point located on the centerline and all following points in order representing points along the hull bottom and up the sides of the boat. Figure 3 shows points defining several typical sections. The program is dimensioned to allow up to 25 points on each half station. (This makes 50 points on each full station after the computer creates a mirror image about

JONBOAT USED IN SAMPLE RUN



STEPPED PLANING HULL

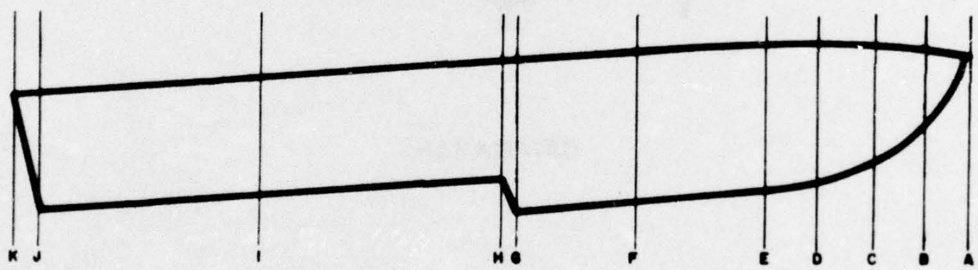
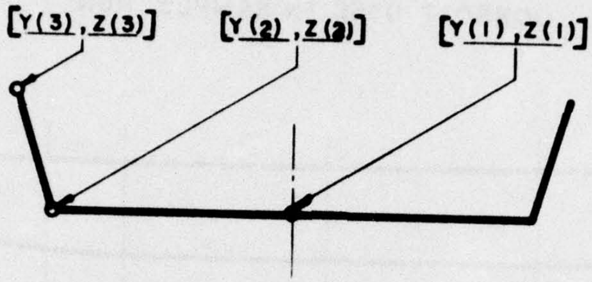
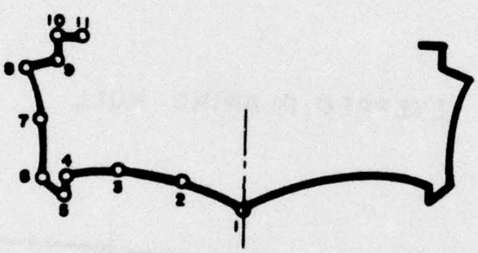


FIGURE 2. CHOOSING STATION LOCATIONS

JONBOAT



CATHEDRAL HULL WITH COAMING



CATAMARAN

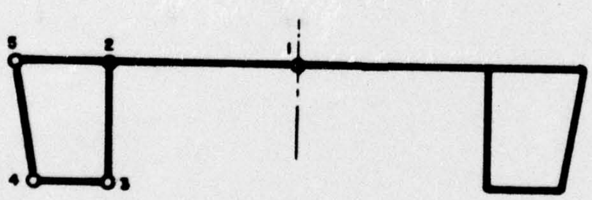


FIGURE 3. DEFINING SECTION SHAPES

the centerline.) The only restrictions on number or location of points are, first, that at least one point must be given for each station (this would define a station with zero area); second, the first point must be on the centerline; and third, the points must be in order around the hull.

3.2 Condition Information

The first item of data for the condition information must be the number of cases to be considered. This can be any integer value greater than zero. Each of the cases has all the information defining its condition and the type of analysis to be done on one data card. The information included on this card is weight of the boat in pounds, longitudinal transverse and vertical centers of gravity in feet, draft in feet, trim and heel in degrees, water density in pounds per cubic foot, and three one-digit control codes which control what values are to be allowed to reach equilibrium. The different methods of operation of the program (which are controlled by the control codes) make use of different items of data on the data card.

For the three control codes, a zero indicates the parameter in question is free to seek equilibrium, while a one indicates the parameter is held constant. The first digit controls the draft, the second digit controls the trim, and the third digit controls the heel angle.

3.2.1 All Parameters Fixed (Control Codes 111)

In this mode of operation, hydrostatic properties are calculated for one condition only. That condition is specified by the draft, trim and heel angle that are put in on the condition information card. Weight and center of gravity are used only to reference metacentric height ($\overline{GM}$), righting arm ($\overline{GZ}$), and restoring forces and moments to.

3.2.2 Two Parameters Fixed, One Parameter Free (Control Codes 110, 101 or 011)

These three modes of operation are used to investigate restoring forces and moments. For instance, with trim angle held constant at zero degrees and draft allowed to seek equilibrium conditions, heel angle could be varied through a range of angles in order to investigate the transverse stability of the boat. In this way, trim angle would be always equal to zero degrees, the displacement would always be correct, and the heel angle would be the specified angle in the different cases. The same technique can be used to obtain pitch righting arm curves and heave restoring force curves.

3.2.3 One Parameter Fixed, Two Parameters Free (Control Codes 100, 010 and 001)

This mode of operation is useful for determining the restoring forces and moments on boats like recreational boats. For example, if

the heel angle is held constant at each of several angles in different cases, while both pitch and draft are allowed to seek equilibrium, a transverse righting arm curve will be obtained for the boat in which variations in trim due to the underwater hull shape are taken into account. This can also be used to determine the effect of heel angle on trim angle. In these modes of operation, the weight of the boat and the center of gravity of the boat are used and the draft, trim and heel given on the *condition information card* are used either as starting conditions or as constant conditions, depending on which parameters are allowed to remain free and which are fixed conditions.

3.2.4 All Parameters Free (Control Codes 000)

This mode of operation is used to determine the equilibrium draft, trim and heel of a given hull form with a specified weight and center of gravity. In this case the draft, trim and heel values given on the condition information card are used as starting values for the iteration.

3.3 Data Card Format

Hull form data and condition information data are entered on standard 80-column computer punch cards in the format indicated in this section.

3.3.1 *Hull Form Data Format*

Card number one of the hull form data is an alphanumeric title describing the boat in the first 69 characters on the card. Card number two contains the number of stations as an integer right-justified in columns 1 through 10. Card number three contains alphanumeric station titles or numbers in a format of 1X, 15A5. If more than 15 stations are used, additional cards are used for the remaining stations. For the first station from the bow, a card is given which has the number of points on the station and the X-distance of the station. The format of this card is I10, F10.4. Following this card is one card for each point on the station. Each of these offset cards has two numbers on it, the Y-coordinate and the Z-coordinate for the point. The format for these cards if 2F10.4. This sequence is repeated for each station on the boat.

3.3.2 Condition Information Card Format

The first card of this section contains the number of cases as a right-justified integer in columns 1 through 10. The remainder of that card can be used for description, if desired, but this description is not read by the program. Following the first card in this section are a number of condition information cards equal to the number of cases. Each of these cards contains the information of weight in pounds, longitudinal center of gravity in feet, transverse center of gravity in feet, vertical center of gravity in feet, draft in feet, trim and heel in degrees, rho (the weight density of the water) in pounds per cubic foot, and the three control codes. These parameters are formatted on the card in a

format of 1X, 8F9.3, 3X, 3I2. Figure 4 shows a condition information card coding form, which is helpful in preparing the data for keypunching.

3.4 Sample Input

Figure 5 shows a sample input for the hull form of a jon boat. Figure 6 shows the condition information for this same jon boat.

4.0 INTERPRETING THE OUTPUT

The first section of the output is a repetition of the hull form data used. The data which defines the boat hull form is printed out in the same format as the cards with the input values. This allows checking of the hull form data. The total number of cases is also printed out in this section. See Appendix C for an example.

The results for each case appear on two pages of output. The first page of the output contains the results of the intermediate calculations for each station. The first line of the output gives the draft, trim and heel in original coordinates. Directly under the draft and trim appear the values in the rotated coordinate system. Appendix C shows a sample of this page of output. Directly under this table is presented the case data used. This is the same data that appears on the condition information card in the same format.

The second page of output for each case is a presentation of the overall calculations. Appendix C presents a sample of this output. In this output values that appear in parenthesis are in the original coordinate system, while values not in parenthesis are in the rotated coordinate system. Where only one value is given, both coordinate systems correspond. Block number one of this output presents the draft, trim and heel of the boat as calculated, as well as the weight and center of gravity. Block number two presents the calculated displacement, center of buoyancy, waterplane area, and center of flotation. Block number three presents overall waterplane length, waterplane beam, maximum draft, maximum section area, the location of the ends of the waterplane, and the wetted surface. Block number four presents the residual moments and forces. (In an equilibrium case, these forces and moments would be zero, or very nearly so. Equilibrium is considered to be reached when changes of less than 0.001 ft. in draft and 0.0001 radians in the two angles are called for.) Block number five presents stability information, both longitudinal and transverse; and block number six presents coefficients.

5.0 PROGRAM ERROR MESSAGES

The program includes one warning message and one error message. The warning message appears in any case where equilibrium is being sought and no equilibrium has been reached after 99 iterations. The format of this warning statement will be:

"WARNING-NO EQUILIBRIUM XX XX .XXXXXE±XX .XXXXXE±XX .XXXXXE±XX"

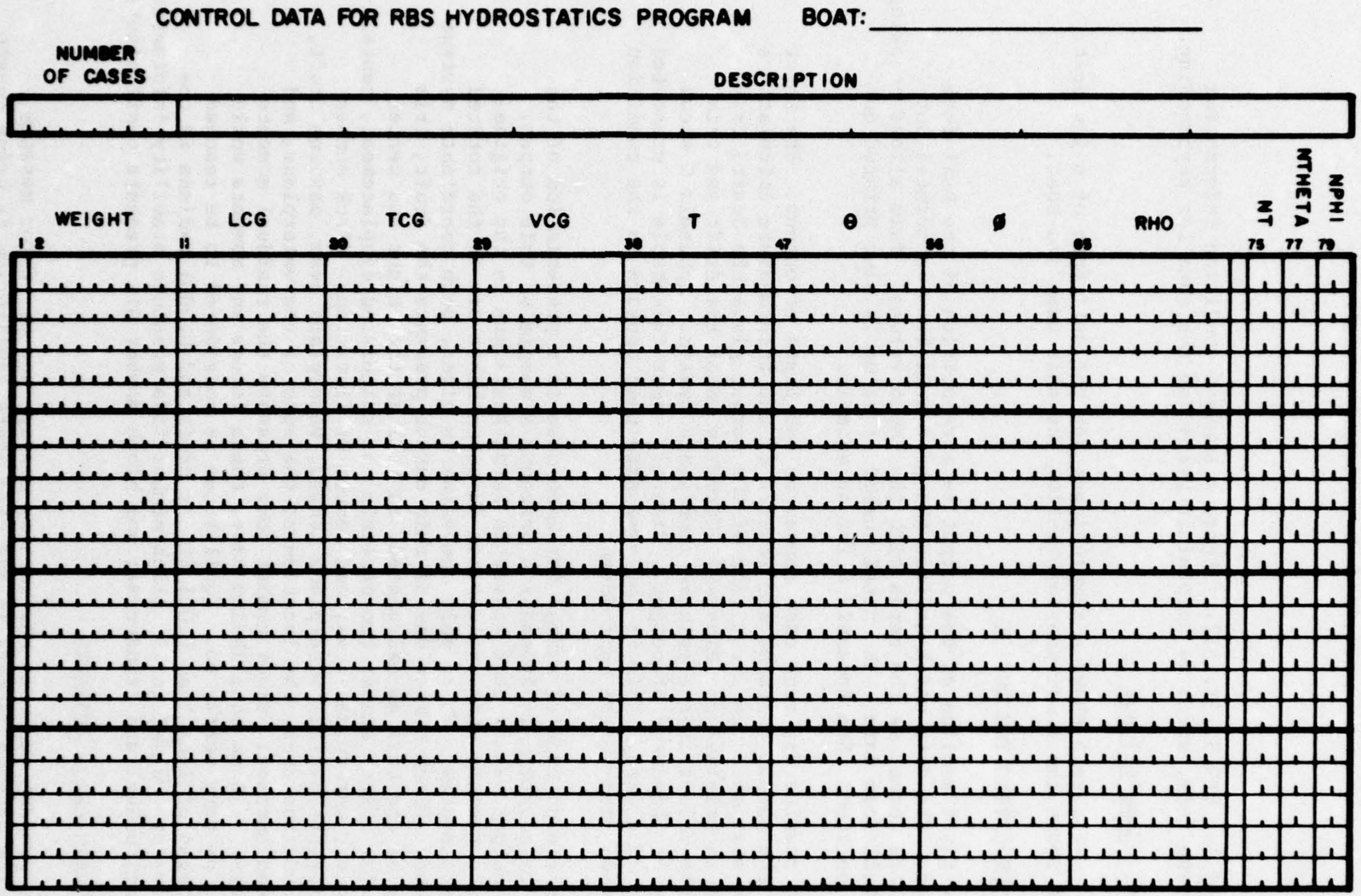


FIGURE 4. CONDITION INFORMATION CARD CODING FORM

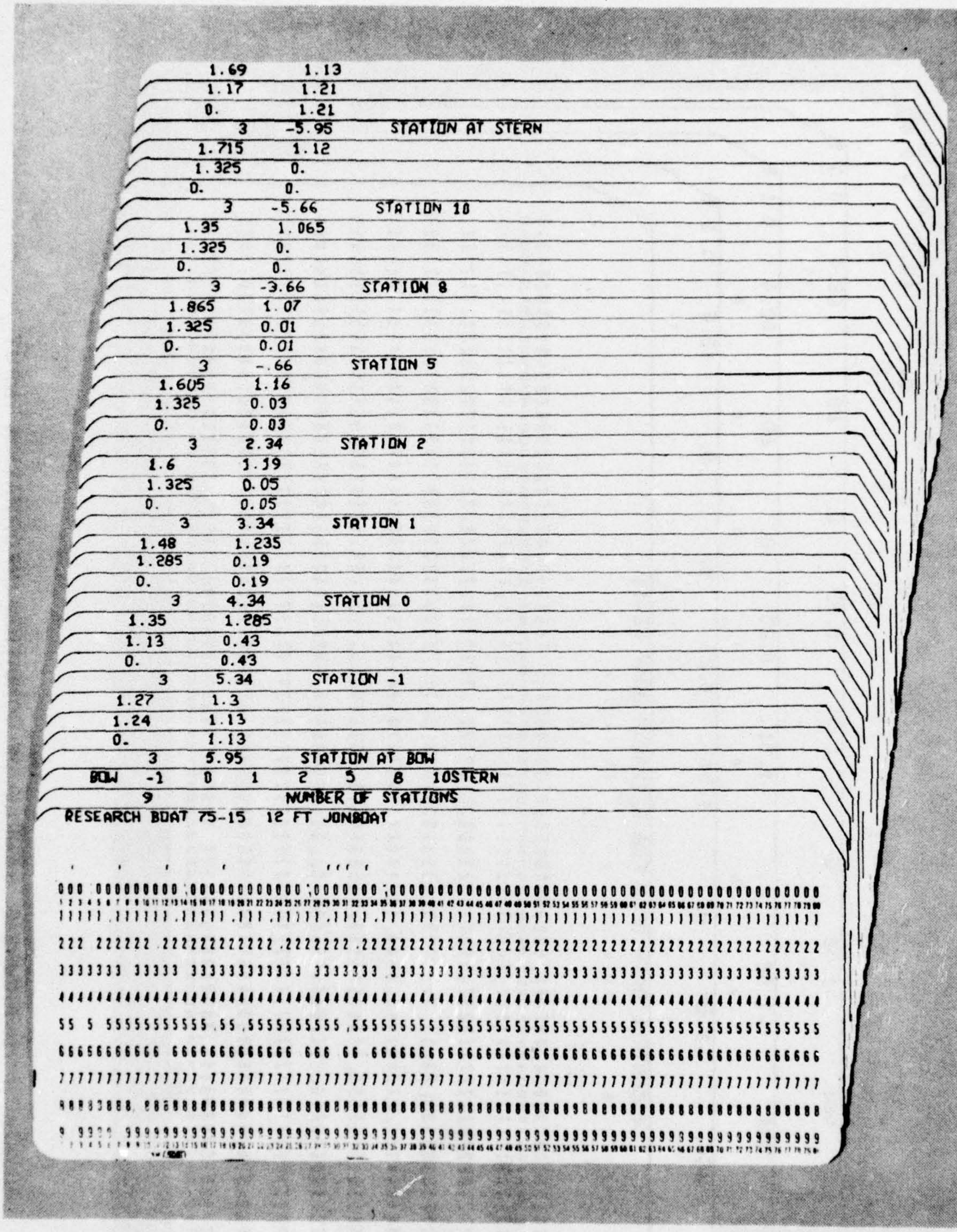


FIGURE 5. SAMPLE OF HULL FORM INPUT

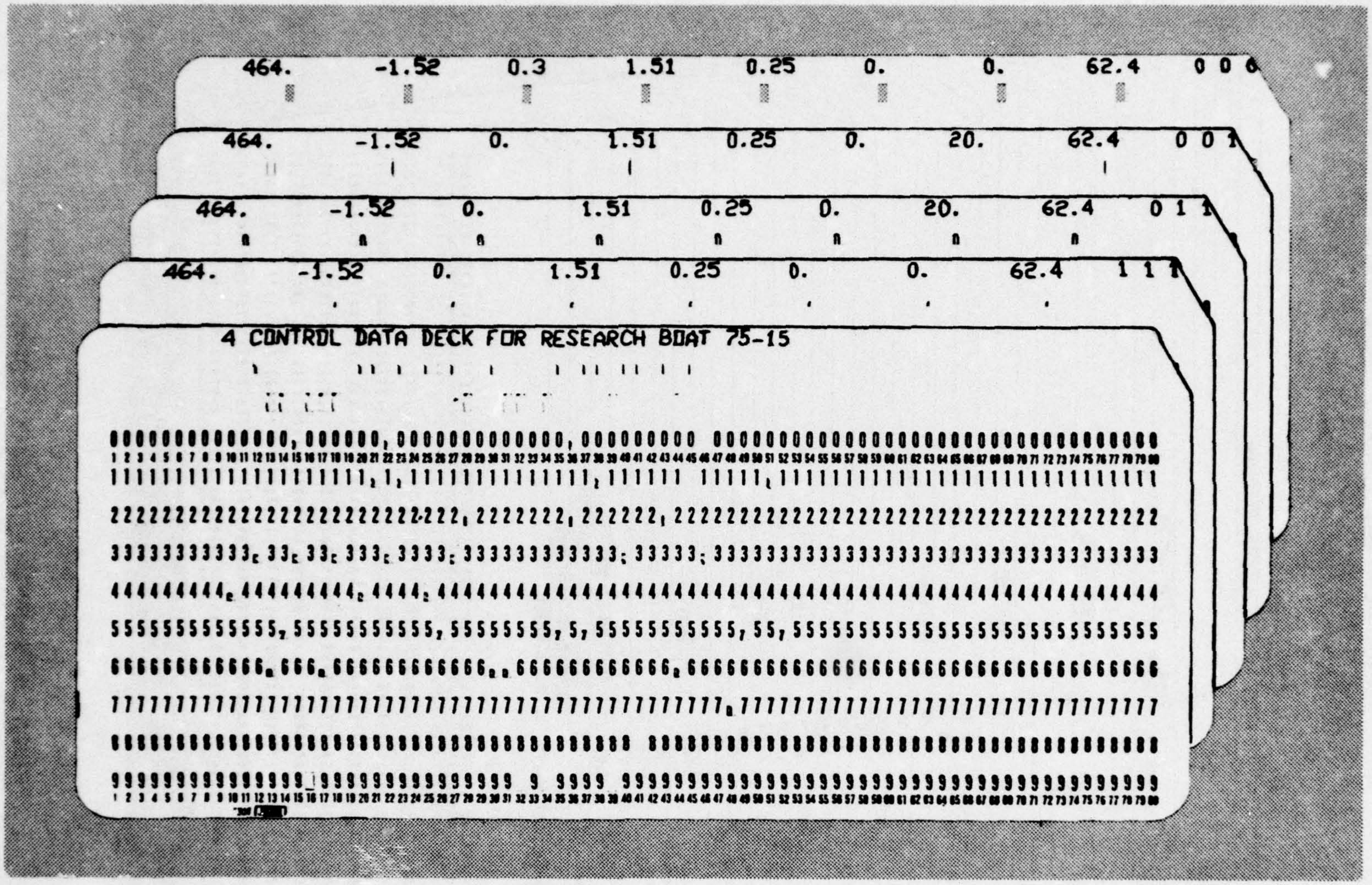


FIGURE 6. SAMPLE OF CONDITION INFORMATION INPUT

The first number after the warning indicates the number of iterations attempted. The second number indicates the total number of equilibrium conditions which were not met. This can be either one, two or three. The last three numbers in scientific notation form are the change in draft, change in trim and change in heel angle from the last iteration.

The second diagnostic generated by the program is of the form:

"CALCS.STOPPED-UNSTABLE .XXXXXE±XX .... .XXXXXE±XX .XXXXXE±XX"

The numbers following this error message are draft, trim, heel, waterplane area, longitudinal metacentric height ($\overline{GM}_L$) and transverse metacentric height ($\overline{GM}_T$). This error and message occurs when one of the restoring forces is too small for stability.

While neither of these error messages prevents further execution of the program, their appearance in the output causes the results to be suspect for that particular case.

APPENDIX A – PROGRAM LISTINGS AND FLOW CHARTS

Listing of Main Program

```
C HYDROSTATICS AND EQUILIBRIUM CHARACTERISTICS PROGRAM
C           DEVELOPED FOR RECREATIONAL BOATING SAFETY PROJECT
C           DEVELOPED AT USCG R+D CENTER   GROTON,CONN.
C           DEVELOPED BY PETER SECREST      SEPTEMBER,1975
C
      INTEGER TITLE(23),NPTS(25)
      REAL X(25),Y(25,50),Z(25,50),YO(25,50),ZO(25,50),NUMBER(25)
      REAL LCG,LCGO,ZLOW(25),A(25),AYM(25),AZM(25),B(25),BYM(25)
      REAL BYI(25),BWP(25),GIRTH(25),DRAFT(25),LCBM,LCB,LCFM,LCF
      REAL LWPI,CA1(25),CA2(25),AYC(25),AZC(25),BYC(25),LMCM,LWL
C SECTION FOR INPUT AND OUTPUT OF HULL FORM DATA
      INPUT=3
      IPRINT=4
      WRITE(IPRINT,42)
      READ(INPUT,1)(TITLE(J),J=1,23)
      WRITE(IPRINT,1)(TITLE(J),J=1,23)
      READ(INPUT,2)NSTA
      WRITE(IPRINT,6)NSTA
      READ(INPUT,5)(NUMBER(J),J=1,NSTA)
      WRITE(IPRINT,5)(NUMBER(J),J=1,NSTA)
      DO 100 N1=1,NSTA
      READ(INPUT,3)NOFFS,X(N1)
      WRITE(IPRINT,6)NOFFS,X(N1)
      NPTS(N1)=2*NOFFS
      DO 100 N2=1,NOFFS
      READ(INPUT,4)YO(N1,N2),ZO(N1,N2)
      WRITE(IPRINT,7)YO(N1,N2),ZO(N1,N2)
      N3=NPTS(N1)-N2+1
      YO(N1,N3)=-YO(N1,N2)
      ZO(N1,N3)=ZO(N1,N2)
  100 CONTINUE
C SECTION FOR INPUT OF CASE DATA
      READ(INPUT,2)NCASES
      WRITE(IPRINT,8)NCASES
      DO 200 N1=1,NCASES
      READ(INPUT,9)WEIGHT,LCGO,TCGO,VCGO,TO,THETAO,PHIO,RHO,NT,NTHETA,
     1NPHI
C BEGINNING OF CALCULATIONS
      VOLUME=WEIGHT/RHO
      PHI=PHIO/57.29578
      COSPHI=COS(PHI)
      SINPHI=SIN(PHI)
      T=TO*COSPHI
      THETA=THETAO*COSPHI/57.29578
      LCG=LCGO
      DO 300 I=1,99
C TRANSFORMATION OF COORDINATES TO HEELED COORDINATES
      TCG=TCGO*COSPHI-VCGO*SINPHI
      VCG=VCGO*COSPHI+TCGO*SINPHI
      DO 350 I1=1,NSTA
      ZLOW(I1)=+100.
```

```
      IPTS=NPTS(I1)
      DO 350 I2=1,IPTS
      Y(I1,I2)=YO(I1,I2)*COSPHI-ZO(I1,I2)*SINPHI
      Z(I1,I2)=ZO(I1,I2)*COSPHI+YO(I1,I2)*SINPHI
      IF(Z(I1,I2).LT.ZLOW(I1))ZLOW(I1)=Z(I1,I2)
  350 CONTINUE
C DETERMINATION OF HYDROSTATICS
      DO 400 K1=1,NSTA
      ZHIGH=T+X(K1)*TAN(THETA)
      NP=NPTS(K1)
      CALL SECT(K1,NP,Y,Z,ZHIGH,A1,AYM1,AZM1,B1,BYM1,BYI1,BWP1,GIRTH1)
      A(K1)=A1
      AYM(K1)=AYM1
      AZM(K1)=AZM1
      B(K1)=B1
      BYM(K1)=BYM1
      BYI(K1)=BYI1
      BWP(K1)=BWP1
      GIRTH(K1)=GIRTH1
      DRAFT(K1)=ZHIGH-ZLOW(K1)
  400 CONTINUE
      CALL ENDPT(1,NSTA,X,DRAFT,XSTART,ISTART)
      CALL ENDPT(NSTA,NSTA,X,DRAFT,XEND,IEND)
      IF(IEND.LT.ISTART.OR.NSTA.LE.1)GO TO 410
      CALL  INTEG(X,A,XSTART,XEND,ISTART,IEND,VDISP,LCBM,BLANK)
      CALL  INTEG(X,AYM,XSTART,XEND,ISTART,IEND,TCBM,BLANK,BLANK)
      CALL  INTEG(X,AZM,XSTART,XEND,ISTART,IEND,VCBM,BLANK,BLANK)
      CALL  INTEG(X,B,XSTART,XEND,ISTART,IEND,AWP,LCFM,LWPI)
      CALL  INTEG(X,BYM,XSTART,XEND,ISTART,IEND,TCFM,BLANK,BLANK)
      CALL  INTEG(X,BYI,XSTART,XEND,ISTART,IEND,TWPI,BLANK,BLANK)
      CALL  INTEG(X,GIRTH,XSTART,XEND,ISTART,IEND,WS,BLANK,BLANK)
      GO TO 420
  410 CONTINUE
      VDISP=0.
      LCBM=0.
      TCBM=0.
      VCBM=0.
      AWP=0.
      LCFM=0.
      LWPI=0.
      TCFM=0.
      TWPI=0.
      WS=0.
  420 CONTINUE
      LCF=0.
      TCF=0.
      IF(AWP.LE.0.0001)GO TO 430
      LCF=LCFM/AWP
      TCF=TCFM/AWP
      LWPI=LWPI-LCFM*LCF
      TWPI=TWPI-TCFM*TCF
  430 CONTINUE
      LCB=0.
      TCB=0.
      VCB=0.
      BML=0.
      BMT=0.
```

```
      IF(VDISP.LE.0.0001)GO TO 440
      LCB=LCBM/VDISP
      TCB=TCBM/VDISP
      VCB=VCBM/VDISP
      BML=LWPI/VDISP
      BMT=TWPI/VDISP
  440 CONTINUE
      GML=BML+VCB-VCG
      GMT=BMT+VCB-VCG
      GZL=(LCG-LCB)*COS(THETA)+(VCG-VCB)*SIN(THETA)
      GZT=TCB-TCG
      LWL=XSTART-XEND
C CHECKING FOR EQUILIBRIUM
      IF(NT.LE.0.AND.AWP.LE.0.001)GO TO 500
      IF(NTHETA.LE.0.AND.GML.LE.0.001)GO TO 500
      IF(NPHI.LE.0.AND.GMT.LE.0.001)GO TO 500
      ITEST=0
      DT=0.
      DTHETA=0.
      DPHI=0.
      IF(NT.GT.0)GO TO 510
      DT=(VOLUME-VDISP)/AWP
      IF(ABS(DT).GT.0.001)ITEST=ITEST+1
  510 CONTINUE
      IF(NTHETA.GT.0)GO TO 520
      DTHETA=GZL/GML
      IF(ABS(DTHETA).GT.0.0001)ITEST=ITEST+1
  520 CONTINUE
      IF(NPHI.GT.0)GO TO 530
      DPHI=GZT/GMT
      IF(ABS(DPHI).GT.0.0001)ITEST=ITEST+1
  530 CONTINUE
      IF(ITEST.LE.0)GO TO 540
      T=T+DT-TCF*DPHI+LCF*DTHETA
      THETA=(THETA+DTHETA)/COSPHI
      PHI=PHI+DPHI
      COSPHI=COS(PHI)
      SINPHI=SIN(PHI)
      THETA=THETA*COSPHI
      IF(NT.GT.0)T=TO*COSPHI
      IF(NTHETA.GT.0)THETA=THETAO*COSPHI/57.29578
  550 CONTINUE
      WRITE(IPRINT,10)I,ITEST,DT,DTHETA,DPHI
      GO TO 540
  500 CONTINUE
      WRITE(IPRINT,11)T,THETA,PHI,AWP,GML,GMT
  540 CONTINUE
C SUPPLEMENTARY CALCULATIONS
      AMAX=0.
      DRMAX=0.
      BEAM=0.
      IF(IEND.LT.ISTART.OR.NSTA.LE.1)GO TO 620
      DO 605 J=1,NSTA
      AYC(J)=0.
      AZC(J)=0.
      BYC(J)=0.
      CA1(J)=0.
```

```
      CA2(J)=0.
  605 CONTINUE
      DO 600 J=ISTART,IEND
      IF(A(J).GT.AMAX)AMAX=A(J)
      IF(DRAFT(J).GT.DRMAX)DRMAX=DRAFT(J)
      IF(BWP(J).GT.BEAM)BEAM=BWP(J)
  600 CONTINUE
      DO 610 J=ISTART,IEND
      IF(A(J).LE.0.0001)GO TO 610
      AYC(J)=AYM(J)/A(J)
      AZC(J)=AZM(J)/A(J)
      IF(B(J).GT.0.0001)BYC(J)=BYM(J)/B(J)
      CA1(J)=A(J)/AMAX
      IF(BWP(J).LE.0.0001.OR.DRAFT(J).LE.0.0001)GO TO 610
      CA2(J)=A(J)/BWP(J)/DRAFT(J)
  610 CONTINUE
  620 CONTINUE
      THETAD=THETA*57.29578
      PHID=PHI*57.29578
      DISP=VDISP*RHO
      LMOM=DISP*GZL
      TMOM=DISP*GZT
      VFORCE=DISP-WEIGHT
      IF(LWL.LE.0.001.OR.BEAM.LE.0.001.OR.DRMAX.LE.0.001)GO TO 630
      CB=VDISP/LWL/BEAM/DRMAX
      CX=AMAX/BEAM/DRMAX
      CP=CB/CX
      CW=AWP/LWL/BEAM
      CVP=CB/CW
      CIL=LWPI/LWL**3/BEAM
      CIT=TWPI/LWL/BEAM**3
      GO TO 640
  630 CONTINUE
      CB=0.
      CX=0.
      CP=0.
      CW=0.
      CVP=0.
      CIL=0.
      CIT=0.
  640 CONTINUE
      T1=T/COSPHI
      THETA1=THETAD/COSPHI
      TCG1=TCG*COSPHI+VCG*SINPHI
      VCG1=VCG*COSPHI-TCG*SINPHI
      TCB1=TCB*COSPHI+VCB*SINPHI
      VCB1=VCB*COSPHI-TCB*SINPHI
      TCF1=TCF*COSPHI+T*SINPHI
      VCF1=T*COSPHI-TCF*SINPHI
C OUTPUT OF RESULTS BY SECTION
      WRITE(IPRINT,40)
      WRITE(IPRINT,52)(TITLE(J),J=1,23)
      WRITE(IPRINT,20)(T1,THETA1,PHID,T,THETAD)
      NS=NSTA/10.
      NS1=10*NS
      IF(NS1.LT.NSTA)NS=NS+1
      DO 900 ISTA=1,NS
```

```
      L=ISTA*10
      K=L-9
      IF(L.GT.NSTA)L=NSTA
      WRITE(IPRINT,21)(NUMBER(J),J=K,L)
      WRITE(IPRINT,22)(X(J),J=K,L)
      WRITE(IPRINT,23)(A(J),J=K,L)
      WRITE(IPRINT,24)(CA1(J),J=K,L)
      WRITE(IPRINT,25)(CA2(J),J=K,L)
      WRITE(IPRINT,26)(AYM(J),J=K,L)
      WRITE(IPRINT,27)(AYC(J),J=K,L)
      WRITE(IPRINT,28)(AZM(J),J=K,L)
      WRITE(IPRINT,29)(AZC(J),J=K,L)
      WRITE(IPRINT,30)(B(J),J=K,L)
      WRITE(IPRINT,31)(BYM(J),J=K,L)
      WRITE(IPRINT,32)(BYC(J),J=K,L)
      WRITE(IPRINT,33)(BYI(J),J=K,L)
      WRITE(IPRINT,34)(BWF(J),J=K,L)
      WRITE(IPRINT,35)(DRAFT(J),J=K,L)
      WRITE(IPRINT,36)(GIRTH(J),J=K,L)
      WRITE(IPRINT,41)
  800 CONTINUE
      WRITE(IPRINT,43)
      WRITE(IPRINT,9)WEIGHT,LCGO,TCGO,VCGO,TO,THETAO,PHIO,KHO,NT,NTHETA,
     $NPHI
C OUTPUT OF COMPLETE RESULTS
      WRITE(IPRINT,40)
      WRITE(IPRINT,50)
      WRITE(IPRINT,51)
      WRITE(IPRINT,52)(TITLE(J),J=1,23)
      WRITE(IPRINT,51)
      WRITE(IPRINT,50)
      WRITE(IPRINT,54)T1,T,DISP
      WRITE(IPRINT,55)THETA1,THETAD,VDISP
      WRITE(IPRINT,56)PHID,LCB
      WRITE(IPRINT,57)WEIGHT,TCB1,TCB
      WRITE(IPRINT,58)LCG,VCB1,VCB
      WRITE(IPRINT,59)TCG1,TCG,AWP
      WRITE(IPRINT,60)VCG1,VCG,LCF
      WRITE(IPRINT,61)TCF1,TCF
      WRITE(IPRINT,62)VCF1,T
      WRITE(IPRINT,53)
      WRITE(IPRINT,50)
      WRITE(IPRINT,63)LWL,LMOM
      WRITE(IPRINT,64)BEAM,GZL
      WRITE(IPRINT,65)DRMAX
      WRITE(IPRINT,66)AMAX,TMOM
      WRITE(IPRINT,67)XSTART,GZT
      WRITE(IPRINT,68)XEND
      WRITE(IPRINT,69)WS,VFORCE
      WRITE(IPRINT,53)
      WRITE(IPRINT,53)
      WRITE(IPRINT,50)
      WRITE(IPRINT,70)LWFI,CB
      WRITE(IPRINT,71)BML,CX
      WRITE(IPRINT,72)GML,CP
      WRITE(IPRINT,73)CW
      WRITE(IPRINT,74)TWPI,CVP
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      WRITE(IPRINT,75)BMT,CIL
      WRITE(IPRINT,76)GMT,CIT
      WRITE(IPRINT,53)
      WRITE(IPRINT,53)
      WRITE(IPRINT,50)
      WRITE(IPRINT,77)
      WRITE(IPRINT,50)
  200 CONTINUE
    1 FORMAT(23A3)
    2 FORMAT(8I10)
    3 FORMAT(I10,F10.4)
    4 FORMAT(8F10.4)
    5 FORMAT(1X,15A5)
    6 FORMAT(1X,I10,F10.4)
    7 FORMAT(1X,2F10.4)
    8 FORMAT(17H NUMBER OF CASES=,I2)
    9 FORMAT(1X,8F9.3,1X,3I2)
   10 FORMAT(23H WARNING-NO EQUILIBRIUM,2I4,3E12.5)
   11 FORMAT(23H CALCS.STOPPED-UNSTABLE,6E12.5)
   20 FORMAT(///19H RESULTS BY SECTION,9X,2HT=,F7.3,13H FT.    THETA=,
     $F7.3,13H DEG.     PHI=,F7.3,5H DEG.,4X,20H**VALUES IN ORIGINAL,
     $14H COORDINATES**,/30X,F7.3,13X,F7.3,16X,4H.000,9X,11H**VALUES IN,
     $23H ROTATED  COORDINATES**)
   21 FORMAT(1X,20HSTATION NUMBER        ,10(5X,A5))
   22 FORMAT(1X,20HX-POSITION        (FT),10F10.3)
   23 FORMAT(1X,20HAREA           (SQ.FT),10F10.3)
   24 FORMAT(1X,20HCA1=AREA/MAX.AREA    ,10F10.3)
   25 FORMAT(1X,20HCA2=AREA/BEAM/DRAFT ,10F10.3)
   26 FORMAT(1X,20HAREA Y-MOMENT(CU.FT),10F10.3)
   27 FORMAT(1X,20HAREA Y-CENTER    (FT),10F10.3)
   28 FORMAT(1X,20HAREA Z-MOMENT(CU.FT),10F10.3)
   29 FORMAT(1X,20HAREA Z-CENTER    (FT),10F10.3)
   30 FORMAT(1X,20HWP WIDTH         (FT),10F10.3)
   31 FORMAT(1X,20HWP Y-MOMENT  (SQ.FT),10F10.3)
   32 FORMAT(1X,20HWP Y-CENTER      (FT),10F10.3)
   33 FORMAT(1X,20HWP Y-INERTIA (CU.FT),10F10.3)
   34 FORMAT(1X,20HWP BEAM(OVERALL)(FT),10F10.3)
   35 FORMAT(1X,20HDRAFT            (FT),10F10.3)
   36 FORMAT(1X,20HGIRTH            (FT),10F10.3)
   40 FORMAT(1H1)
   41 FORMAT(1H0)
   42 FORMAT(21H1HULL FORM DATA USED-)
   43 FORMAT(11H0DATA USED-)
   50 FORMAT(1X,72(1H*))
   51 FORMAT(1X,1H*,70X,1H*)
   52 FORMAT(1X,1H*,23A3,2H *)
   53 FORMAT(1X,1H*,34X,1H*,35X,1H*)
   54 FORMAT(1X,8H*T       (,F10.3,1H),F10.3,25H FT    *DISPLACEMENT        ,
     $F10.3,8H LB     *)
   55 FORMAT(1X,8H*THETA (,F10.3,1H),F10.3,25H DEG   *VOLUME DISP.        ,
     $F10.3,8H CU.FT *)
   56 FORMAT(1X,8H*PHI    (,F10.3,1H),5X,15H0.000 DEG   *LCB,15X,F10.3,
     $8H FT     *)
   57 FORMAT(1X,19H*WEIGHT                ,F10.3,14H LB    *TCB    (,F10.3,
     $1H),F10.3,8H FT     *)
   58 FORMAT(1X,19H*LCG                   ,F10.3,14H FT    *VCB    (,F10.3,
     $1H),F10.3,8H FT     *)
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59 FORMAT(1X,8H*TCG    (,F10.3,1H),F10.3,25H FT    *WATERPLANE AREA    ,
  $F10.3,8H SQ.FT *)
60 FORMAT(1X,8H*VCG    (,F10.3,1H),F10.3,25H FT    *LCF                ,
  $F10.3,8H FT     *)
61 FORMAT(1X,1H*,34X,8H*TCF    (,F10.3,1H),F10.3,8H FT     *)
62 FORMAT(1X,1H*,34X,8H*VCF    (,F10.3,1H),F10.3,8H FT     *)
63 FORMAT(1X,19H*WATERPLANE LENGTH ,F10.3,18H FT    *LONG.MOMENT,7X,
  $F10.3,8H FT.LB *)
64 FORMAT(20H *WATERPLANE BEAM    ,F10.3,25H FT    *LONG.GZ            ,
  $F10.3,8H FT     *)
65 FORMAT(1X,19H*MAXIMUM DRAFT      ,F10.3,7H  FT   *,35X,1H*)
66 FORMAT(20H *MAX.SECTION AREA   ,F10.3,25H SQ.FT*TRANS.MOMENT        ,
  $F10.3,8H FT.LB *)
67 FORMAT(20H *FWD WATERPLANE END,F10.3,25H FT    *TRANS.GZ            ,
  $F10.3,8H FT     *)
68 FORMAT(20H *AFT WATERPLANE END,F10.3,7H FT    *,35X,1H*)
69 FORMAT(20H *WETTED SURFACE     ,F10.3,25H SQ.FT*VERTICAL FORCE      ,
  8F10.3,8H LB     *)
70 FORMAT(20H *LONG.INERTIA       ,F10.3,25H FT4   *BLOCK COEFFICIENT ,
  &4X,F8.5,5X,1H*)
71 FORMAT(10H *BML      ,10X,F10.3,26H FT    *MAX.SECTION COEF    ,
  &3X,F8.5,5X,1H*)
72 FORMAT(10H *GML      ,10X,F10.3,26H FT    *PRISMATIC COEF      ,
  &3X,F8.5,5X,1H*)
73 FORMAT(1X,1H*,34X,20H*WATERPLANE COEF.    ,3X,F8.5,5X,1H*)
74 FORMAT(15H *TRANS.INERTIA,5X,F10.3,26H FT4  *VERT.PRISMATIC COEF,
  &3X,F8.5,5X,1H*)
75 FORMAT(10H *BMT      ,10X,F10.3,26H FT    *LONG.INERTIA COEF   ,
  &3X,F8.5,5X,1H*)
76 FORMAT(10H *GMT      ,10X,F10.3,26H FT    *TRANS.INERTIA COEF ,
  &3X,F8.5,5X,1H*)
77 FORMAT(1X,1H*,41H VALUES IN PARENTHESIS ARE IN NON-ROTATED,
  $21H ORIGINAL COORDINATES,3X,1H*)
   STOP
   END
```

Flowchart of Main Program

```
              /''''''''''''''''''''''"
             :        BEGIN          :
              "....................../
                        I
                        I---I HYDROSTATICS AND EQUILIBRIUM   _
                        I   ICHARACTERISTICS PROGRAM         _
                        I   I DEVELOPED FOR RECREATIONAL     _
                        I   IBOATING SAFETY PROJECT          _
                        I   I DEVELOPED AT USCG R+D CENTER   _
                        I   IGROTON,CONN.                    _
                        I   I DEVELOPED BY PETER SECREST     _
                        I   ISEPTEMBER,1975                  _
                        I
                        I
..................................................
:        INTEGER TITLE(23),NPTS(25)             :
: REAL X(25),Y(25,50),Z(25,50),YD(25,50),       :
: ZD(25,50),NUMBER(25)                          :
: REAL LCG,LCGD,ZLOW(25),A(25),AYM(25),AZM(     :
: 25),B(25),BYM(25)                             :
: REAL BYI(25),BWF(25),GIRTH(25),DRAFT(25),     :
: LCBM,LCB,LCFM,LCF                             :
: REAL LWPI,CA1(25),CA2(25),AYC(25),AZC(25)     :
: ,BYC(25),LMOM,LWL                             :
:................................................:
                        I
                        I---I SECTION FOR INPUT AND OUTPUT OF_
                        I   IHULL FORM DATA                  _
                        I
                        I
..................................................
:                  INPUT=3                       :
:                  IPRINT=4                      :
:................................................:
                        I
                        I
  /''''''''''''''''''''''''''''''''''''''''''''''/
 /              WRITE(IPRINT,42)                /
/............................................../
                        I
                        I
  /''''''''''''''''''''''''''''''''''''''''''''''/
 /       READ(INPUT,1)(TITLE(J),J=1,23)         /
/............................................../
                        I
                        I
  /''''''''''''''''''''''''''''''''''''''''''''''/
 /     WRITE(IPRINT,1)(TITLE(J),J=1,23)         /
/............................................../
                        I
```

```
                              I
        /'''''''''''''''''''''''''''''''''''''''''/
       /          READ(INPUT,2)NSTA              /
      /.........................................../
                              I
                              I
        /'''''''''''''''''''''''''''''''''''''''''/
       /          WRITE(IPRINT,6)NSTA            /
      /.........................................../
                              I
                              I
        /'''''''''''''''''''''''''''''''''''''''''/
       /  READ(INPUT,5)(NUMBER(J),J=1,NSTA)      /
      /.........................................../
                              I
                              I
        /'''''''''''''''''''''''''''''''''''''''''/
       /  WRITE(IPRINT,5)(NUMBER(J),J=1,NSTA)    /
      /.........................................../
                              I
                              I
      :............................................:
A---->:           DO 100 N1=1,NSTA                 :
A     :............................................:
A                             I
A                             I
A       /'''''''''''''''''''''''''''''''''''''''''/
A      /        READ(INPUT,3)NOFFS,X(N1)         /
A     /.........................................../
A                             I
A                             I
A       /'''''''''''''''''''''''''''''''''''''''''/
A      /        WRITE(IPRINT,6)NOFFS,X(N1)       /
A     /.........................................../
A                             I
A                             I
A     :............................................:
A     :           NPTS(N1)=2*NOFFS                 :
A     :............................................:
A                             I
A                             I
A     :............................................:
A B-->:           DO 100 N2=1,NOFFS                :
A B   :............................................:
A B                           I
A B                           I
A B     /'''''''''''''''''''''''''''''''''''''''''/
A B    /   READ(INPUT,4)YO(N1,N2),ZO(N1,N2)      /
A B   /.........................................../
A B                           I
A B                           I
A B     /'''''''''''''''''''''''''''''''''''''''''/
A B    /   WRITE(IPRINT,7)YO(N1,N2),ZO(N1,N2)    /
A B   /.........................................../
A B                           I
```

```
A B                                     I
A B        ......................................................
A B        :              N3=NPTS(N1)-N2+1                      :
A B        :              YO(N1,N3)=-YO(N1,N2)                  :
A B        :              ZO(N1,N3)=ZO(N1,N2)                   :
A B        :....................................................:
A B                                     I
A B          I  100_                    I
A B        ......................................................
-----------:                    CONTINUE                        :
           :....................................................:
                                        I
                                        I---I SECTION FOR INPUT OF CASE DATA _
                                        I
                                        I
           /''''''''''''''''''''''''''''''''''''''''''''''''''''/
          /              READ(INPUT,2)NCASES                   /
         /....................................................../
                                        I
                                        I
           /''''''''''''''''''''''''''''''''''''''''''''''''''''/
          /              WRITE(IPRINT,8)NCASES                 /
         /....................................................../
                                        I
                                        I
           ......................................................
A--------->:              DO 200 N1=1,NCASES                    :
A          :....................................................:
A                                       I
A                                       I
A          /''''''''''''''''''''''''''''''''''''''''''''''''''''''/
A         / READ(INPUT,9)WEIGHT,LCGO,TCGO,VCGO,TO,               /
A        / THETAO,PHIO,RHO,NT,NTHETA,NPHI                        /
A       /......................................................./
A                                       I
A                                       I---I BEGINNING OF CALCULATIONS     _
A                                       I
A                                       I
A          ......................................................
A          :              VOLUME=WEIGHT/RHO                     :
A          :              PHI=PHIO/57.29578                     :
A          :              COSPHI=COS(PHI)                       :
A          :              SINPHI=SIN(PHI)                       :
A          :              T=TO*COSPHI                           :
A          :       THETA=THETAO*COSPHI/57.29578                 :
A          :              LCG=LCGO                              :
A          :....................................................:
A                                       I
A                                       I
A          ......................................................
A B------->:              DO 300 I=1,99                         :
A B        :....................................................:
A B                                     I
A B                                     I---I TRANSFORMATION OF COORDINATES  _
A B                                     I   ITO HEELED COORDINATES           _
A B                                     I
A B                                     I
```

```
A B        ............................................
A B        :     TCG=TCGO*COSPHI-VCGO*SINPHI          :
A B        :     VCG=VCGO*COSPHI+TCGO*SINPHI          :
A B        :..........................................:
A B                            I
A B                            I
A B        ............................................
A B C------------->:           DO 350 I1=1,NSTA       :
A B C      :..........................................:
A B C                          I
A B C                          I
A B C      ............................................
A B C      :              ZLOW(I1)=+100.              :
A B C      :              IPTS=NPTS(I1)               :
A B C      :..........................................:
A B C                          I
A B C                          I
A B C      ............................................
A B C D------------->:         DO 350 I2=1,IPTS       :
A B C D    :..........................................:
A B C D                        I
A B C D                        I
A B C D    ............................................
A B C D    : Y(I1,I2)=YO(I1,I2)*COSPHI-ZO(I1,I2)*     :
A B C D    : SINPHI                                   :
A B C D    : Z(I1,I2)=ZO(I1,I2)*COSPHI+YO(I1,I2)*     :
A B C D    : SINPHI                                   :
A B C D    :..........................................:
A B C D                        I
A B C D                        I
A B C D    /''''''''''''''''''''''''''''''''''''''''''  FALSE
A B C D    <       IF(Z(I1,I2).LT.ZLOW(I1))           >-------------I
A B C D    '........................................./              I
A B C D                        I  TRUE                              I
A B C D                        I                                    I
A B C D    ............................................             I
A B C D    : ZLOW(I1)=Z(I1,I2)                        :             I
A B C D    :..........................................:             I
A B C D                        I                                    I
A B C D                        O<-----------------------------------
A B C D      I  350_           I
A B C D    ............................................
A B -------------------:       CONTINUE                :
A B        :..........................................:
A B                            I
A B                            I---I DETERMINATION OF HYDROSTATICS  _
A B                            I
A B                            I
A B                            I
A B        ............................................
A B C------------->:           DO 400 K1=1,NSTA       :
A B C      :..........................................:
A B C                          I
A B C                          I
A B C      ............................................
A B C      :        ZHIGH=T+X(K1)*TAN(THETA)          :
A B C      :              NP=NPTS(K1)                 :
A B C      :..........................................:
A B C                          I
```

```
A B C                                   I
A B C    ..............................................
A B C    : : CALL SECT(K1,FP,Y,Z,ZHIGH,A1,AYM1,      : :
A B C    : : AZM1,B1,BYM1,BYI1,BWP1,GIRTH1)          : :
A B C    :.:.........................................:.:
A B C                                   I
A B C                                   I
A B C    ..............................................
A B C    :               A(K1)=A1                      :
A B C    :             AYM(K1)=AYM1                    :
A B C    :             AZM(K1)=AZM1                    :
A B C    :               B(K1)=B1                      :
A B C    :             BYM(K1)=BYM1                    :
A B C    :             BYI(K1)=BYI1                    :
A B C    :             BWP(K1)=BWP1                    :
A B C    :           GIRTH(K1)=GIRTH1                  :
A B C    :       DRAFT(K1)=ZHIGH-ZLOW(K1)              :
A B C    :.............................................:
A B C                                   I
A B C      I 400_                       I
A B C    ..............................................
A B -----:                  CONTINUE                   :
A B      :.............................................:
A B                                     I
A B                                     I
A B      ..............................................
A B      : : CALL ENDPT(1,NSTA,X,DRAFT,XSTART,       : :
A B      : : ISTART)                                 : :
A B      :.:.........................................:.:
A B                                     I
A B                                     I
A B      ..............................................
A B      : : CALL ENDPT(NSTA,NSTA,X,DRAFT,XEND,      : :
A B      : : IEND)                                   : :
A B      :.:.........................................:.:
A B                                     I
A B                                     I
A B       /''''''''''''''''''''''''''''''''''''''''''''"   TRUE
A B      < IF(IEND.LT.ISTART.OR.NSTA.LE.1)GO TO 410  >---------------------------------0
A B       "............................................/                               Z
A B                                     I  FALSE                                       Z
A B                                     I                                              Z
A B                                     I                                              Z
A B      ..............................................                                Z
A B      : : CALL INTEG(X,A,XSTART,XEND,ISTART,      : :                               Z
A B      : : IEND,VDISP,LCEM,BLANK)                  : :                               Z
A B      :.:.........................................:.:                               Z
A B                                     I                                              Z
A B                                     I                                              Z
A B      ..............................................                                Z
A B      : : CALL INTEG(X,AYM,XSTART,XEND,ISTART,    : :                               Z
A B      : : IEND,TC3M,BLANK,BLANK)                  : :                               Z
A B      :.:.........................................:.:                               Z
A B                                     I                                              Z
```

```
: : CALL INTEG(X,AZM,XSTART,XEND,ISTART,   : :
: : IEND,VCBM,BLANK,BLANK)                 : :

                     I
                     I

: : CALL INTEG(X,E,XSTART,XEND,ISTART,     : :
: : IEND,AMP,LCFM,LMPI)                    : :

                     I
                     I

: : CALL INTEG(X,EYM,XSTART,XEND,ISTART,   : :
: : IEND,TCFM,BLANK,BLANK)                 : :

                     I
                     I

: : CALL INTEG(X,EYI,XSTART,XEND,ISTART,   : :
: : IEND,TMPI,BLANK,BLANK)                 : :

                     I
                     I

: : CALL INTEG(X,GIRTH,XSTART,XEND,        : :
: : ISTART,IEND,WS,BLANK,BLANK)            : :

                     I
                     I

        :       GO TO 420      :----------------------------------0

                    0<--------------------------------------------0

  I  410_           I
:                CONTINUE                   :
:                VDISP=0.                   :
:                LCBM=0.                    :
:                TCBM=0.                    :
:                VCBM=0.                    :
:                 AMP=0.                    :
:                LCFM=0.                    :
:                LMPI=0.                    :
:                TCFM=0.                    :
:                TMPI=0.                    :
:                 WS=0.                     :

                    I
                    0<--------------------------------------------0
```

```
 I  420_              I
......................................................
:                 CONTINUE                           :
:                  LCF=0.                            :
:                  TCF=0.                            :
:....................................................:
                      I
                      I
/''''''''''''''''''''''''''''''''''''''''''''''''''''   TRUE
<          IF(AWP.LE.0.0001)GO TO 430               >-------------------------------0
 ".................................................../                              Z
                      I  FALSE                                                      Z
                      I                                                             Z
                      I                                                             Z
......................................................                              Z
:              LCF=LCFM/AWP                          :                              Z
:              TCF=TCFM/AWP                          :                              Z
:           LWPI=LWPI-LCFM*LCF                       :                              Z
:           TWPI=TWPI-TCFM*TCF                       :                              Z
:....................................................:                              Z
                      I                                                             Z
                      0<------------------------------------------------------------0
 I  430_              I
......................................................
:                 CONTINUE                           :
:                  LCB=0.                            :
:                  TCB=0.                            :
:                  VCB=0.                            :
:                  BML=0.                            :
:                  BMT=0.                            :
:....................................................:
                      I
                      I
/''''''''''''''''''''''''''''''''''''''''''''''''''''   TRUE
<          IF(VDISP.LE.0.0001)GO TO 440             >-------------------------------0
 ".................................................../                              Z
                      I  FALSE                                                      Z
                      I                                                             Z
                      I                                                             Z
......................................................                              Z
:             LCB=LCBM/VDISP                         :                              Z
:             TCB=TCBM/VDISP                         :                              Z
:             VCB=VCBM/VDISP                         :                              Z
:             BML=LWPI/VDISP                         :                              Z
:             BMT=TWPI/VDISP                         :                              Z
:....................................................:                              Z
                      I                                                             Z
                      0<------------------------------------------------------------0
 I  440_              I
......................................................
:                 CONTINUE                           :
:            GML=BML+VCB-VCG                         :
:            GMT=BMT+VCB-VCG                         :
: GZL=(LCG-LCB)*COS(THETA)+(VCG-VCB)*SIN(            :
: THETA)                                             :
:              GZT=TCB-TCG                           :
:            LWL=XSTART-XEND                         :
:....................................................:
```

```
                      I
                      I---I CHECKING FOR EQUILIBRIUM
                      I
                      I
 /''''''''''''''''''''''''''''''''''''''''''''" TRUE
< IF(NT.LE.0.AND.AMP.LE.0.001)GO TO 500       >--------------------------------0
 "............................................/                                 Z
                      I  FALSE                                                 Z
                      I                                                        Z
                      I                                                        Z
 /''''''''''''''''''''''''''''''''''''''''''''" TRUE                           Z
< IF(NTHETA.LE.0.AND.CML.LE.0.001)GO TO       >--------------------------------V
< 500                                         >                                Z
 "............................................/                                 Z
                      I  FALSE                                                 Z
                      I                                                        Z
                      I                                                        Z
 /''''''''''''''''''''''''''''''''''''''''''''" TRUE                           Z
< IF(NPHI.LE.0.AND.GMT.LE.0.001)GO TO 500     >--------------------------------V
 "............................................/                                 Z
                      I  FALSE                                                 Z
                      I                                                        Z
..............................................                                 Z
:                 ITEST=0                    :                                 Z
:                  DT=0.                     :                                 Z
:                DTHETA=0.                   :                                 Z
:                 DPHI=0.                    :                                 Z
:............................................:                                 Z
                      I                                                        Z
                      I                                                        Z
 /''''''''''''''''''''''''''''''''''''''''''''" TRUE                           Z
<          IF(NT.GT.0)GO TO 510               >-----------------------------0  Z
 "............................................/                              X  Z
                      I  FALSE                                              X  Z
                      I                                                     X  Z
                      I                                                     X  Z
..............................................                              X  Z
:          DT=(VOLUME-VDISP)/AMP             :                              X  Z
:............................................:                              X  Z
                      I                                                     X  Z
                      I                                                     X  Z
 /''''''''''''''''''''''''''''''''''''''''''''" FALSE                       X  Z
<          IF(ABS(DT).GT.0.001)               >------------I                X  Z
 "............................................/            I                X  Z
                      I  TRUE                              I                X  Z
                      I                                    I                X  Z
..............................................             I                X  Z
:             ITEST=ITEST+1                  :             I                X  Z
:............................................:             I                X  Z
                      I                                    I                X  Z
                      0<-------------------------------------------------- -0  Z
   I  510_            I                                                        Z
..............................................                                 Z
:                 CONTINUE                   :                                 Z
:............................................:                                 Z
                      I                                                        Z
```

```
                          I
  /''''''''''''''''''''''''''''''''''''''''''''''  TRUE
 <           IF(NTHETA.GT.0)GO TO 520              >-----------------------------0
  '............................................../                               X
                          I  FALSE                                               X
                          I                                                      X
                          I                                                      X
 .................................................                               X
 :              DTHETA=GZL/GML                   :                               X
 :...............................................:                               X
                          I                                                      X
                          I                                                      X
  /''''''''''''''''''''''''''''''''''''''''''''''  FALSE                         X
 <         IF(ABS(DTHETA).GT.0.0001)               >-----------I                 X
  '............................................../             I                 X
                          I  TRUE                              I                 X
                          I                                    I                 X
 .................................................             I                 X
 : ITEST=ITEST+1                                 :             I                 X
 :...............................................:             I                 X
                          I                                    I                 X
                          0<-------------------------------------------------------0
   I  520_                I
 .................................................
 :               CONTINUE                        :
 :...............................................:
                          I
                          I
  /''''''''''''''''''''''''''''''''''''''''''''''  TRUE
 <           IF(NPHI.GT.0)GO TO 530                >-----------------------------0
  '............................................../                               X
                          I  FALSE                                               X
                          I                                                      X
                          I                                                      X
 .................................................                               X
 :               DPHI=GZT/GMT                    :                               X
 :...............................................:                               X
                          I                                                      X
                          I                                                      X
  /''''''''''''''''''''''''''''''''''''''''''''''  FALSE                         X
 <          IF(ABS(DPHI).GT.0.0001)                >-----------I                 X
  '............................................../             I                 X
                          I  TRUE                              I                 X
                          I                                    I                 X
 .................................................             I                 X
 : ITEST=ITEST+1                                 :             I                 X
 :...............................................:             I                 X
                          I                                    I                 X
                          0<-------------------------------------------------------0
   I  530_                I
 .................................................
 :               CONTINUE                        :
 :...............................................:
                          I
                          I
```

```
 /'''''''''''''''''''''''''''''''''''''''''''  TRUE
<        IF(ITEST.LE.0)GO TO 540            >----------------0
 ".........................................../                X
                    I  FALSE
                    I
                    I
...............................................
:       T=T+DT-TCF*DPHI+LCF*DTHETA            :
:     THETA=(THETA+DTHETA)/COSPHI             :
:              PHI=PHI+DPHI                   :
:            COSPHI=COS(PHI)                  :
:            SINPHI=SIN(PHI)                  :
:          THETA=THETA*COSPHI                 :
:.............................................:
                    I
                    I
 /'''''''''''''''''''''''''''''''''''''''''''  FALSE
<             IF(NT.GT.0)                   >-----------I
 ".........................................../            I
                    I  TRUE                               I
                    I                                     I
...............................................           I
:              T=TO*COSPHI                    :           I
:.............................................:           I
                    I                                     I
                    0<------------------------------------
                    I
 /'''''''''''''''''''''''''''''''''''''''''''  FALSE
<           IF(NTHETA.GT.0)                 >-----------I
 ".........................................../            I
                    I  TRUE                               I
                    I                                     I
...............................................           I
: THETA=THETAO*COSPHI/57.29578                :           I
:.............................................:           I
                    I                                     I
                    0<------------------------------------
   I  300_          I
...............................................
:                 CONTINUE                    :
:.............................................:
                    I
                    I
 /''''''''''''''''''''''''''''''''''''''''''''/
/  WRITE(IPRINT,10)I,ITEST,DT,DTHETA,DPHI/
/............................................/
                    I
                    I
        /''''''''''''''''''''"
        :     GO TO 540      :---------------------------V
        ".................../
                    0<-------------------------------------0
   I  500_          I
...............................................
:                 CONTINUE                    :
:.............................................:
```

```
A                                 I                                                                           X
A                                 I                                                                           X
A            /''''''''''''''''''''''''''''''''''''''''''/                                                     X
A           /   WRITE(IPRINT,11)T,THETA,PHI,AMP,GML,   /                                                      X
A          /   GMT                                    /                                                       X
A         /........................................../                                                        X
A                                 I                                                                           X
A                                 O<--------------------------------------------------------------------------O
A           I  540_               I
A         ..........................................
A         :              CONTINUE                  :
A         :........................................:
A                                 I
A                                 I---I SUPPLEMENTARY CALCULATIONS
A                                 I
A                                 I
A         ..........................................
A         :              AMAX=0.                   :
A         :              DRMAX=0.                  :
A         :              BEAM=0.                   :
A         :........................................:
A                                 I
A                                 I
A         /''''''''''''''''''''''''''''''''''''''''''  TRUE
A        < IF(IEND.LT.ISTART.OR.NSTA.LE.1)GO TO 620 >------------------------------------------------------------O
A         "........................................./                                                           Z
A                                 I  FALSE                                                                    Z
A                                 I                                                                           Z
A                                 I                                                                           Z
A         ..........................................                                                          Z
A B------>:           DO 605 J=1,NSTA              :                                                          Z
A B       :........................................:                                                          Z
A B                               I                                                                           Z
A B                               I                                                                           Z
A B       ..........................................                                                          Z
A B       :              AYC(J)=0.                 :                                                          Z
A B       :              AZC(J)=0.                 :                                                          Z
A B       :              BYC(J)=0.                 :                                                          Z
A B       :              CA1(J)=0.                 :                                                          Z
A B       :              CA2(J)=0.                 :                                                          Z
A B       :........................................:                                                          Z
A B                               I                                                                           Z
A B         I  605_               I                                                                           Z
A B       ..........................................                                                          Z
A --------:              CONTINUE                  :                                                          Z
A         :........................................:                                                          Z
A                                 I                                                                           Z
A                                 I                                                                           Z
A         ..........................................                                                          Z
A B------>:         DO 600 J=ISTART,IEND           :                                                          Z
A B       :........................................:                                                          Z
A B                               I                                                                           Z
A B                               I                                                                           Z
A B       /''''''''''''''''''''''''''''''''''''''''''  FALSE                                                   Z
A B      <           IF(A(J).GT.AMAX)               >----------I                                              Z
A B       "........................................./           I                                              Z
A B                               I  TRUE                       I
```

```
A B                        I                                    I                        Z
A B   ..............................................           I                        Z
A B   :                 AMAX=A(J)                  :           I                        Z
A B   :............................................:           I                        Z
A B                        I                                    I                        Z
A B                        O<-----------------------------------                        Z
A B                        I                                                             Z
A B   /''''''''''''''''''''''''''''''''''''''''''"  FALSE                               Z
A B   <          IF(DRAFT(J).GT.DRMAX)            >------------I                        Z
A B   "............................................/             I                        Z
A B                        I  TRUE                              I                        Z
A B                        I                                    I                        Z
A B   ..............................................           I                        Z
A B   : DRMAX=DRAFT(J)                             :           I                        Z
A B   :............................................:           I                        Z
A B                        I                                    I                        Z
A B                        O<-----------------------------------                        Z
A B                        I                                                             Z
A B   /''''''''''''''''''''''''''''''''''''''''''"  FALSE                               Z
A B   <          IF(BWP(J).GT.BEAM)               >------------I                        Z
A B   "............................................/             I                        Z
A B                        I  TRUE                              I                        Z
A B                        I                                    I                        Z
A B   ..............................................           I                        Z
A B   :                BEAM=BWP(J)                 :           I                        Z
A B   :............................................:           I                        Z
A B                        I                                    I                        Z
A B                        O<-----------------------------------                        Z
A B     ( 600_             I                                                             Z
A B   ..............................................                                    Z
A ----:                 CONTINUE                   :                                    Z
A     :............................................:                                    Z
A                          I                                                             Z
A                          I                                                             Z
A     ..............................................                                    Z
A B-->:           DO 610 J=ISTART,IEND             :                                    Z
A B   :............................................:                                    Z
A B                        I                                                             Z
A B                        I                                                             Z
A B   /''''''''''''''''''''''''''''''''''''''''''"  TRUE                                Z
A B   <      IF(A(J).LE.0.0001)GO TO 610          >-------------------------------O   Z
A B   "............................................/                                X   Z
A B                        I  FALSE                                                X   Z
A B                        I                                                        X   Z
A B                        I                                                        X   Z
A B   ..............................................                              X   Z
A B   :              AYC(J)=AYM(J)/A(J)            :                              X   Z
A B   :              AZC(J)=AZM(J)/A(J)            :                              X   Z
A B   :............................................:                              X   Z
A B                        I                                                        X   Z
A B                        I                                                        X   Z
A B   /''''''''''''''''''''''''''''''''''''''''''"  FALSE                         X   Z
A B   <          IF(B(J).GT.0.0001)               >------------I                  X   Z
A B   "............................................/             I                  X   Z
A B                        I  TRUE                              I                  X   Z
A B                        I                                    I                  X   Z
```

```
A B      .........................................              I                                  X  Z
A B      : BYC(J)=BYM(J)/B(J)                    :              I                                  X  Z
A B      :.......................................:              I                                  X  Z
A B                         I                                   I                                  X  Z
A B                         O<----------------------------------                                   X  Z
A B                         I                                                                      X  Z
A B      .........................................                                                 X  Z
A B      :           CA1(J)=A(J)/AMAX            :                                                 X  Z
A B      :.......................................:                                                 X  Z
A B                         I                                                                      X  Z
A B                         I                                                                      X  Z
A B      /'''''''''''''''''''''''''''''''''''''''"  TRUE                                           X  Z
A B      < IF(BWP(J).LE.0.0001.OR.DRAFT(J).LE.0.  >------------------------------------------------V  Z
A B      < 0001)GO TO 610                         >                                                X  Z
A B      "......................................../                                                 X  Z
A B                         I  FALSE                                                               X  Z
A B                         I                                                                      X  Z
A B                         I                                                                      X  Z
A B      .........................................                                                 X  Z
A B      :     CA2(J)=A(J)/BWP(J)/DRAFT(J)       :                                                 X  Z
A B      :.......................................:                                                 X  Z
A B                         I                                                                      X  Z
A B                         O<-----------------------------------------------------------------------O  Z
A B       I 610_            I                                                                         Z
A B      .........................................                                                    Z
A -------:              CONTINUE                 :                                                    Z
A        :.......................................:                                                    Z
A                           I                                                                         Z
A                           O<-------------------------------------------------------------------------O
A         I 620_            I
A        .........................................
A        :              CONTINUE                 :
A        :        THETAD=THETA*57.29578          :
A        :          PHID=PHI*57.29578            :
A        :           DISP=VDISP*RHO              :
A        :           LMOM=DISP*GZL               :
A        :           TMOM=DISP*GZT               :
A        :         VFORCE=DISP-WEIGHT            :
A        :.......................................:
A                           I
A                           I
A        /'''''''''''''''''''''''''''''''''''''''"  TRUE
A        < IF(LWL.LE.0.001.OR.BEAM.LE.0.001.OR.   >--------------------------------------------------O
A        < DRMAX.LE.0.001)GO TO 630               >                                                  Z
A        "......................................../                                                  Z
A                           I  FALSE                                                                 Z
A                           I                                                                        Z
A                           I                                                                        Z
A        .........................................                                                   Z
A        :       CB=VDISP/LWL/BEAM/DRMAX         :                                                   Z
A        :         CX=AMAX/BEAM/DRMAX            :                                                   Z
A        :              CP=CB/CX                 :                                                   Z
A        :          CW=AWP/LWL/BEAM              :                                                   Z
A        :             CVP=CB/CW                 :                                                   Z
A        :        CIL=LWPI/LWL**3/BEAM           :                                                   Z
A        :        CIT=TWPI/LWL/BEAM**3           :                                                   Z
A        :.......................................:                                                   Z
A                           I                                                                        Z
```

```
GO TO 640

630_
CONTINUE
CB=0.
CX=0.
CP=0.
CW=0.
CVP=0.
CIL=0.
CIT=0.

640_
CONTINUE
T1=T/COSPHI
THETA1=THETAD/COSPHI
TCG1=TCG*COSPHI+VCG*SINPHI
VCG1=VCG*COSPHI-TCG*SINPHI
TCB1=TCB*COSPHI+VCB*SINPHI
VCB1=VCB*COSPHI-TCB*SINPHI
TCF1=TCF*COSPHI+T*SINPHI
VCF1=T*COSPHI-TCF*SINPHI

I---I OUTPUT OF RESULTS BY SECTION

WRITE(IPRINT,40)

WRITE(IPRINT,52)(TITLE(J),J=1,27)

WRITE(IPRINT,20)(T1,THETA1,PHID,T,
THETAD)

NS=NSTA/10.
NS1=10*NS
```

```
A                                  I
A              /''''''''''''''''''''''''''''''''''''''''''''"  FALSE
A             <            IF(NS1.LT.NSTA)                  >-------------I
A              ".........................................../              I
A                                  I  TRUE                                I
A                                  I                                      I
A             .............................................               I
A             :                NS=NS+1                     :              I
A             :............................................:              I
A                                  I                                      I
A                                  O<-------------------------------------
A                                  I
A             .............................................
A B--------->:            DO 800 ISTA=1,NS                 :
A B           :............................................:
A B                                I
A B                                I
A B           .............................................
A B           :                L=ISTA*10                   :
A B           :                 K=L-9                      :
A B           :............................................:
A B                                I
A B                                I
A B            /''''''''''''''''''''''''''''''''''''''''''''"  FALSE
A B           <             IF(L.GT.NSTA)                   >-------------I
A B            ".........................................../              I
A B                                I  TRUE                                I
A B                                I                                      I
A B           .............................................               I
A B           :                 L=NSTA                     :              I
A B           :............................................:              I
A B                                I                                      I
A B                                O<-------------------------------------
A B                                I
A B             /'''''''''''''''''''''''''''''''''''''''''''/
A B            /   WRITE(IPRINT,21)(NUMBER(J),J=K,L)       /
A B           /.........................................../
A B                                I
A B                                I
A B             /'''''''''''''''''''''''''''''''''''''''''''/
A B            /      WRITE(IPRINT,22)(K(J),J=K,L)         /
A B           /.........................................../
A B                                I
A B                                I
A B             /'''''''''''''''''''''''''''''''''''''''''''/
A B            /      WRITE(IPRINT,23)(A(J),J=K,L)         /
A B           /.........................................../
A B                                I
A B                                I
A B             /'''''''''''''''''''''''''''''''''''''''''''/
A B            /      WRITE(IPRINT,24)(CA1(J),J=K,L)       /
A B           /.........................................../
A B                                I
A B                                I
A B             /'''''''''''''''''''''''''''''''''''''''''''/
A B            /      WRITE(IPRINT,25)(CA2(J),J=K,L)       /
A B           /.........................................../
A B                                I
```

```
WRITE(IPRINT,26)(AYM(J),J=K,L)
WRITE(IPRINT,27)(AYC(J),J=K,L)
WRITE(IPRINT,28)(AZM(J),J=K,L)
WRITE(IPRINT,29)(AZC(J),J=K,L)
WRITE(IPRINT,30)(B(J),J=K,L)
WRITE(IPRINT,31)(BYM(J),J=K,L)
WRITE(IPRINT,32)(BYC(J),J=K,L)
WRITE(IPRINT,33)(BYI(J),J=K,L)
WRITE(IPRINT,34)(BWP(J),J=K,L)
WRITE(IPRINT,35)(DRAFT(J),J=K,L)
WRITE(IPRINT,36)(GIRTH(J),J=K,L)
```

```
A B           /''''''''''''''''''''''''''''''''''''''''''/
A B          /              WRITE(IPRINT,41)             /
A B         /.........................................../
A B                                 I
A B          I  800_                I
A B         ............................................
A ----------:                  CONTINUE                :
A           :..........................................:
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /            WRITE(IPRINT,43)             /
A           /........................................./
A                                   :
A                                   I
A               /''''''''''''''''''''''''''''''''''''''''/
A              / WRITE(IPRINT,9)WEIGHT,LCGO,TCGO,VCGO,   /
A             / TO,THETAO,PHIO,RHO,NT,NTHETA,NPHI        /
A            /........................................./
A                                   I
A                                   I---I OUTPUT OF COMPLETE RESULTS
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /            WRITE(IPRINT,40)             /
A           /........................................./
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /            WRITE(IPRINT,50)             /
A           /........................................./
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /            WRITE(IPRINT,51)             /
A           /........................................./
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /   WRITE(IPRINT,52)(TITLE(J),J=1,23)     /
A           /........................................./
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /            WRITE(IPRINT,51)             /
A           /........................................./
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /            WRITE(IPRINT,50)             /
A           /........................................./
A                                   I
A                                   I
A             /''''''''''''''''''''''''''''''''''''''''/
A            /       WRITE(IPRINT,54)T1,T,DISP         /
A           /........................................./
A                                   I
                                    I
```

```
WRITE(IPRINT,55)THETA1,THETAD,VDISP
        I
WRITE(IPRINT,56)PHID,LCB
        I
WRITE(IPRINT,57)WEIGHT,TCB1,TCB
        I
WRITE(IPRINT,58)LCG,VCB1,VCB
        I
WRITE(IPRINT,59)TCG1,TCG,AWP
        I
WRITE(IPRINT,60)VCG1,VCG,LCF
        I
WRITE(IPRINT,61)TCF1,TCF
        I
WRITE(IPRINT,62)VCF1,T
        I
WRITE(IPRINT,53)
        I
WRITE(IPRINT,50)
        I
WRITE(IPPINT,63)LWL,LMOM
        I
WRITE(IPPINT,64)BEAM,GZL
```

```
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /         WRITE(IPRINT,65)DAMAX          /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /       WRITE(IPRINT,66)AMAX,TMOM        /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /      WRITE(IPRINT,67)XSTART,GZT        /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /          WRITE(IPRINT,68)XEND          /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /       WRITE(IPRINT,69)WS,VFOPCE        /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /            WRITE(IPRINT,53)            /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /            WRITE(IPRINT,53)            /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /            WRITE(IPRINT,50)            /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /        WRITE(IPRINT,70)LWPI,CB         /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /        WRITE(IPRINT,71)BML,CX          /
/......................................../
                     I
                     I
  /''''''''''''''''''''''''''''''''''''''''/
 /        WRITE(IPRINT,72)GML,CP          /
/......................................../
                     I
                     I
```

```
WRITE(IPRINT,73)CW

WRITE(IPRINT,74)TWPI,CVP

WRITE(IPRINT,75)BMT,CIL

WRITE(IPRINT,76)GMT,CIT

WRITE(IPRINT,53)

WRITE(IPRINT,53)

WRITE(IPRINT,50)

WRITE(IPRINT,77)

WRITE(IPRINT,50)

200_
CONTINUE
```

```
I---I 1 FORMAT(23A3)                        _
I   I 2 FORMAT(8I10)                        _
I   I 3 FORMAT(I10,F10.4)                   _
I   I 4 FORMAT(8F10.4)                      _
I   I 5 FORMAT(1X,15A5)                     _
I   I 6 FORMAT(1X,I10,F10.4)                _
I   I 7 FORMAT(1X,2F10.4)                   _
I   I 8 FORMAT(17H NUMBER OF CASES=,        _
I   II2)                                    _
I   I 9 FORMAT(1X,8F9.3,1X,3I2)             _
I   I 10 FORMAT(25H WARNING-NO              _
I   IEQUILIBRIUM,2I4,3E12.5)                _
I   I 11 FORMAT(25H CALCS.STOPPED-          _
I   IUNSTABLE,6E12.5)                       _
I   I 20 FORMAT(///19H RESULTS BY           _
I   ISECTION,9X,2HT=,F7.3,13H FT.           _
I   ITHETA=, $F7.3,13H DEG. PHI=,F7.3_
I   I5H DEG.,4X,20H**VALUES IN              _
I   IORIGINAL, $14H COORDINATES**,/         _
I   I30X,F7.3,13X,F7.3,16X,4H.000,9X,_
I   I11H**VALUES IN, $23H ROTATED           _
I   ICOORDINATES**)                         _
I   I 21 FORMAT(1X,20HSTATION NUMBER        _
I   I10(5X,A5))                             _
I   I 22 FORMAT(1X,20HX-POSITION (FT)_
I   I10F10.3)                               _
I   I 23 FORMAT(1X,20HAREA (SQ.FT),         _
I   I10F10.3)                               _
I   I 24 FORMAT(1X,20HCA1=AREA/MAX.         _
I   IAREA ,10F10.3)                         _
I   I 25 FORMAT(1X,20HCA2=AREA/BEAM/        _
I   IDRAFT ,10F10.3)                        _
I   I 26 FORMAT(1X,20HAREA Y-MOMENT(        _
I   I(CU.FT),10F10.3)                       _
I   I 27 FORMAT(1X,20HAREA Y-CENTER (_
I   IFT),10F10.3)                           _
I   I 28 FORMAT(1X,20HAREA Z-MOMENT(        _
I   I(CU.FT),10F10.3)                       _
I   I 29 FORMAT(1X,20HAREA Z-CENTER (_
I   IFT),10F10.3)                           _
I   I 30 FORMAT(1X,20HWP WIDTH (FT),        _
I   I10F10.3)                               _
I   I 31 FORMAT(1X,20HWP Y-MOMENT (SQ_
I   IFT),10F10.3)                           _
I   I 32 FORMAT(1X,20HWP Y-CENTER (FT_
I   I),10F10.3)                             _
I   I 33 FORMAT(1X,20HWP Y-INERTIA (        _
I   ICU.FT),10F10.3)                        _
```

```
| 34 FORMAT(1X,20HWP BEAM(OVERALL
|(FT),10F10.3)
| 35 FORMAT(1X,20HDRAFT (FT),
|10F10.3)
| 36 FORMAT(1X,20HGIRTH (FT),
|10F10.3)
| 40 FORMAT(1H1)
| 41 FORMAT(1H0)
| 42 FORMAT(21H1HULL FORM DATA
|USED-)
| 43 FORMAT(11H0DATA USED-)
| 50 FORMAT(1X,72(1H*))
| 51 FORMAT(1X,1H*,70X,1H*)
| 52 FORMAT(1X,1H*,23A3,2H *)
| 53 FORMAT(1X,1H*,34X,1H*,35X,1H
|)
| 54 FORMAT(1X,8H*T (,F10.3,1H),
|F10.3,25H FT *DISPLACEMENT , $
|F10.3,8H LB *)
| 55 FORMAT(1X,8H*THETA (,F10.3,
|1H),F10.3,25H DEG *VOLUME DISP.
| $F10.3,8H CU.FT *)
| 56 FORMAT(1X,8H*PHI (,F10.3,1H)
|5X,15H0.000 DEG *LCB,15X,F10.3,
|8H FT *)
| 57 FORMAT(1X,19H*WEIGHT ,F10.3,
|14H LB *TCB (,F10.3, $1H),F10.3,
|8H FT *)
| 58 FORMAT(1X,19H*LCG ,F10.3,14H
|FT *VCB (,F10.3, $1H),F10.3,8H
|FT *)
| 59 FORMAT(1X,8H*TCG (,F10.3,1H)
|F10.3,25H FT *WATERPLANE AREA ,
|F10.3,8H SQ.FT *)
| 60 FORMAT(1X,8H*VCG (,F10.3,1H)
|F10.3,25H FT *LCF , $F10.3,8H FT
|*)
| 61 FORMAT(1X,1H*,34X,8H*TCF (,
|F10.3,1H),F10.3,8H FT *)
| 62 FORMAT(1X,1H*,34X,8H*VCF (,
|F10.3,1H),F10.3,8H FT *)
| 63 FORMAT(1X,19H*WATERPLANE
|LENGTH ,F10.3,18H FT *LONG.
|MOMENT,7X, $F10.3,8H FT.LB *)
| 64 FORMAT(20H *WATERPLANE BEAM
|F10.3,25H FT *LONG.GZ , $F10.3,
|8H FT *)
| 65 FORMAT(1X,19H*MAXIMUM DRAFT
|F10.3,7H FT *,35X,1H*)
```

```
I     I 66 FORMAT(20H *MAX.SECTION AREA_
I     I,F10.3,25H SQ.FT*TRANS.MOMENT , _
I     IF10.3,8H FT.LB *)               _
I     I 67 FORMAT(20H *FWD WATERPLANE  _
I     IEND,F10.3,25H FT *TRANS.G7 , $  _
I     IF10.3,3H FT *)                  _
I     I 68 FORMAT(20H *AFT WATERPLANE  _
I     IEND,F10.3,7H FT *,35X,1H*)      _
I     I 69 FORMAT(20H *WETTED SURFACE ,_
I     IF10.3,25H SQ.FT*VERTICAL FORCE ,_
I     I$F10.3,8H LB *)                 _
I     I 70 FORMAT(20H *LONG.INERTIA ,  _
I     IF10.3,25H FT4 *BLOCK COEFFICIENT_
I     I, 44X,F8.5,5X,1H*)              _
I     I 71 FORMAT(10H *BML ,10X,F10.3, _
I     I26H FT *MAX.SECTION COEF , 43X, _
I     IF8.5,5X,1H*)                    _
I     I 72 FORMAT(10H *GML ,10X,F10.3, _
I     I26H FT *PRISMATIC COEF , 43X,F8._
I     I5,5X,1H*)                       _
I     I 73 FORMAT(1X,1H*,34X,20H*      _
I     IWATERPLANE COEF. ,3X,F8.5,5X,1H*_
I     I 74 FORMAT(15H *TRANS.INERTIA,5X_
I     IF10.3,26H FT4 *VERT.PRISMATIC   _
I     ICOEF, 43X,F8.5,5X,1H*)          _
I     I 75 FORMAT(10H *BMT ,10X,F10.3, _
I     I26H FT *LONG.INERTIA COEF , 43X,_
I     IF8.5,5X,1H*)                    _
I     I 76 FORMAT(10H *GMT ,10X,F10.3, _
I     I26H FT *TRANS.INERTIA COEF , 43X_
I     IF8.5,5X,1H*)                    _
I     I 77 FORMAT(1X,1H*,41H VALUES IN _
I     IPARENTHESIS ARE IN NON-ROTATED, _
I     I21H ORIGINAL COORDINATES,8X,1H*)_
I
I
/''''''''''''''''''''"
:        STOP        :
"..................../
```

Listing of Subroutine SECT

```
      SUBROUTINE SECT(I,NP,Y,Z,ZHIGH,A,AYM,AZM,B,BYM,BYI,EWP,GIRTH)
      DIMENSION Y(25,50),Z(25,50)
      A=0.
      AYM=0.
      AZM=0.
      B=0.
      BYM=0.
      BYI=0.
      GIRTH=0.
      YMAX=-100.
      YMIN=+100.
      Y1=Y(I,1)
      Z1=ZHIGH-Z(I,1)
      DO 10 J=2,NP
      Y2=Y(I,J)
      DY=Y2-Y1
      Z2=ZHIGH-Z(I,J)
      DZ=Z2-Z1
      IF(Z1.GT.0.0001.AND.Z2.GT.0.0001)GO TO 11
      IF(Z1.GT.0.0001.AND.Z2.LE.0.0001)GO TO 12
      IF(Z1.LE.0.0001.AND.Z2.GT.0.0001)GO TO 13
      GO TO 14
   11 CONTINUE
      DA=DY*(Z1+Z2)/2.
      YAVG=(Y1+Y2)/2.
      DAYM=Z1*DY*YAVG+DZ*DY*(Y1+2.*DY/3.)/2.
      DAZM=Z1*DY*Z1/2.+DZ*DY*(Z1+DZ/3.)/2.
      DGIRTH=SQRT(DY*DY+DZ*DZ)
      GO TO 15
   12 CONTINUE
      DY=-DY*Z1/DZ
      DA=DY*Z1/2.
      YAVG=Y1+DY/2.
      DAYM=DA*(Y1+DY/3.)
      DAZM=DA*Z1/3.
      Y0=Y1+DY
      IF(Y0.GT.YMAX)YMAX=Y0
      DGIRTH=SQRT(DY*DY+Z1*Z1)
      GO TO 15
   13 CONTINUE
      DY=DY*Z2/DZ
      DA=DY*Z2/2.
      YAVG=Y2-DY/2.
      DAYM=DA*(Y2-DY/3.)
      DAZM=DA*Z2/3.
      Y0=Y2-DY
      IF(Y0.LT.YMIN)YMIN=Y0
      DGIRTH=SQRT(DY*DY+Z2*Z2)
   15 CONTINUE
      A=A+DA
      B=B+DY
```

```
      AYM=AYM+DAYM
      AZM=AZM+DAZM
      BYM=BYM+DY*YAVG
      BYI=BYI+DY*(YAVG*YAVG+DY*DY/12.)
      GIRTH=GIRTH+DGIRTH
   14 CONTINUE
      Y1=Y2
      Z1=Z2
   10 CONTINUE
      BWP=YMAX-YMIN
      IF(BWP.LE.0.0001)BWP=0.
      AZM=A*ZHIGH-AZM
      RETURN
      END
```

Flowchart of Subroutine SECT

```
              ..............................................
              "   SUBROUTINE SECT(I,NP,Y,Z,ZHIGH,A,AYM,    /
              "  AZM,B,BYM,BYI,BWP,GIRTH)                 /
               "........................................./
                                  I
                                  I
              ..............................................
              :        DIMENSION Y(25,50),Z(25,50)          :
              :                A=0.                         :
              :              AYM=0.                         :
              :              AZM=0.                         :
              :                B=0.                         :
              :              BYM=0.                         :
              :              BYI=0.                         :
              :            GIRTH=0.                         :
              :             YMAX=-100.                      :
              :             YMIN=+100.                      :
              :               Y1=Y(I,1)                     :
              :               Z1=ZHIGH-Z(I,1)               :
              :.............................................:
                                  I
                                  I
              ..............................................
A------------>:            DO 10 J=2,NP                     :
A             :.............................................:
A                                 I
A                                 I
A             ..............................................
A             :               Y2=Y(I,J)                     :
A             :               DY=Y2-Y1                      :
A             :               Z2=ZHIGH-Z(I,J)               :
A             :               DZ=Z2-Z1                      :
A             :.............................................:
A                                 I
A                                 I
A             /''''''''''''''''''''''''''''''''''''''''''''"   TRUE
A             < IF(Z1.GT.0.0001.AND.Z2.GT.0.0001)GO TO      >--------------------------------------0
A             < 11                                          >                                      Z
A              "........................................../                                       Z
A                                 I  FALSE                                                         Z
A                                 I                                                                Z
A                                 I                                                                Z
A             /''''''''''''''''''''''''''''''''''''''''''''"   TRUE                                Z
A             < IF(Z1.GT.0.0001.AND.Z2.LE.0.0001)GO TO      >-----------------------------------0  Z
A             < 12                                          >                                   X  Z
A              "........................................../                                    X  Z
A                                 I  FALSE                                                    X  Z
```

```
< IF(Z1.LE.0.0001.AND.Z2.GT.0.0001)GO TO     TRUE
< 13
                    I FALSE

            GO TO 14

                   0<
  I   11_
                CONTINUE
          DA=DY*(Z1+Z2)/2.
          YAVG=(Y1+Y2)/2.
  DAYM=Z1*DY*YAVG+DZ*DY*(Y1+2.*DY/3.)/2.
  DAZM=Z1*DY*Z1/2.+DZ*DY*(Z1+DZ/3.)/2.
         DGIRTH=SQRT(DY*DY+DZ*DZ)

            GO TO 15

                   0<
  I   12_
                CONTINUE
               DY=-DY*Z1/DZ
               DA=DY*Z1/2.
              YAVG=Y1+DY/2.
            DAYM=DA*(Y1+DY/3.)
              DAZM=DA*Z1/3.
                YO=Y1+DY

              IF(YO.GT.YMAX)                FALSE
                    I TRUE
                 YMAX=YO
                   0<
```

```
                     I
..........................................
:     DGIRTH=SQRT(DY*DY+Z1*Z1)           :
:........................................:
                     I
                     I
        /''''''''''''''''''''"
        :     GO TO 15       :--------------------------------------V
        "..................../

                   0<-------------------------------------------0
    I    13_       I
..........................................
:            CONTINUE                    :
:           DY=DY*Z2/D2                  :
:           DA=DY*Z2/2.                  :
:          YAVG=Y2-DY/2.                 :
:       DAYM=DA*(Y2-DY/3.)               :
:         DAZM=DA*Z2/3.                  :
:           Y0=Y2-DY                     :
:........................................:
                     I
                     I
/''''''''''''''''''''''''''''''''''''''''"  FALSE
<           IF(Y0.LT.YMIN)               >------------I
"......................................../            I
                     I   TRUE                         I
                     I                                I
..........................................            I
:            YMIN=Y0                     :            I
:........................................:            I
                     I                                I
                   0<---------------------------------
                     I
..........................................
:      DGIRTH=SQRT(DY*DY+Z2*Z2)          :
:........................................:
                     I
                   0<-------------------------------------------0
    I    15_       I
..........................................
:            CONTINUE                    :
:             A=A+DA                     :
:             B=B+DY                     :
:          AYM=AYM+DAYM                  :
:          AZM=AZM+DAZM                  :
:         BYM=BYM+DY*YAVG                :
:  BYI=BYI+DY*(YAVG*YAVG+DY*DY/12.)      :
:        GIRTH=GIRTH+DGIRTH              :
:........................................:
                     I
                   0<-------------------------------------------0
```

```
 A          I   14_             I
 A     ..........................................................
 A     :                     CONTINUE                           :
 A     :                      Y1=Y2                             :
 A     :                      Z1=Z2                             :
 A     :........................................................:
 A                                  I
 A          I   10_                 I
 A     ..........................................................
 ------:                     CONTINUE                           :
       :........................................................:
                                    I
                                    I
       ..........................................................
       :                   BWF=YMAX-YMIN                        :
       :........................................................:
                                    I
                                    I
        /''''''''''''''''''''''''''''''''''''''''''''''''''''''"  FALSE
       <                 IF(BWP.LE.0.0001)                      >-------------I
        "......................................................./             I
                                    I   TRUE                                  I
                                    I                                         I
       ..........................................................             I
       :                       BWF=0.                           :             I
       :........................................................:             I
                                    I                                         I
                                    O<----------------------------------------
                                    I
       ..........................................................
       :                   AZM=AZHIGH-AZM                       :
       :........................................................:
                                    I
                                    I
                    /''''''''''''''''''''''''''''"
                   :           RETURN            :
                    "............................/
```

Listing of Subroutine ENDPT

```
      SUBROUTINE ENDPT(I,NSTA,X,DRAFT,X0,J0)
      DIMENSION DRAFT(25),X(25)
      K=1
      IF(I.EQ.NSTA)K=-1
      X0=X(I)
      J0=I
      IF(DRAFT(I).GT.0.)GO TO 3
      DO 1 J=2,NSTA
      J0=I+K*(J-1)
      IF(DRAFT(J0).GE.0.)GO TO 2
    1 CONTINUE
    2 CONTINUE
      J1=J0-K
      X0=(X(J0)+X(J1))/2.
      DY=DRAFT(J0)-DRAFT(J1)
      IF(ABS(DY).LT.0.0001)GO TO 3
      X0=X(J0)-DRAFT(J0)*(X(J0)-X(J1))/DY
    3 CONTINUE
      RETURN
      END
```

Flowchart of Subroutine ENDPT

```
               ..............................................
               .  SUBROUTINE ENDPT(I,NSTA,X,DRAFT,XO,      /
               .  JO)                                     /
               ............................................/
                                  I
                                  I
               ..............................................
               :        DIMENSION DRAFT(25),X(25)           :
               :                 K=1                        :
               :............................................:
                                  I
                                  I
               /''''''''''''''''''''''''''''''''''''''''''''  FALSE
              <              IF(I.EQ.NSTA)                  >------------I
               ............................................/             I
                                  I  TRUE                                 I
                                  I                                       I
               ..............................................            I
               :                 K=-1                       :            I
               :............................................:            I
                                  I                                       I
                                  0<--------------------------------------
                                  I
               ..............................................
               :                XO=X(I)                     :
               :                 JO=I                       :
               :............................................:
                                  I
                                  I
               /''''''''''''''''''''''''''''''''''''''''''''  TRUE
              <         IF(DRAFT(I).GT.0.)GO TO 3           >----------------------------------0
               ............................................/                                   Z
                                  I  FALSE                                                      Z
                                  I                                                             Z
                                  I                                                             Z
               ..............................................                                  Z
  A---------->:            DC 1  J=2,NSTA                   :                                  Z
  A           :.............................................:                                  Z
  A                               I                                                             Z
  A                               I                                                             Z
  A           ..............................................                                   Z
  A           :             JO=I+K*(J-1)                    :                                  Z
  A           :.............................................:                                  Z
  A                               I                                                             Z
  A                               I                                                             Z
```

```
      IF(DRAFT(JO).GE.0.)GO TO 2          TRUE  -> 2
               I  FALSE
   1_
               CONTINUE
               I
               0<-----
   2_
               CONTINUE
               J1=JO-K
          XO=(X(JO)+X(J1))/2.
        DY=DRAFT(JO)-DRAFT(J1)
               I
      IF(ABS(DY).LT.0.0001)GO TO 3        TRUE  -> 3
               I  FALSE
   XO=X(JO)-DRAFT(JO)*(X(JO)-X(J1))/DY
               I
               0<-----
   3_
               CONTINUE
               I
               RETURN
```

Listing of Subroutine INTEG

```
      SUBROUTINE INTEG(X,Y,XSTART,XEND,ISTART,IEND,R,R1,R2)
      DIMENSION X(25),Y(25)
      R=0.
      R1=0.
      R2=0.
      Y1=0.
      X1=XSTART
      DO 1 I=ISTART,IEND
      DX=X1-X(I)
      DY=Y(I)-Y1
      R=R+DX*(Y1+DY/2.)
      R1=R1+DX*Y1*(X1-DX/2.)+DX*DY/2.*(X1-2.*DX/3.)
      R2=R2+DX**3*Y1/12.+DX**3*DY/36.+DX*Y1*(X1-DX/2.)**2+DX*DY/2.*
     $(X1-2.*DX/3.)**2
      X1=X(I)
      Y1=Y(I)
    1 CONTINUE
      DX=X(IEND)-XEND
      R=R+DX*Y(IEND)/2.
      R1=R1+DX*Y(IEND)*(X(IEND)-DX/3.)/2.
      R2=R2+DX**3*Y(IEND)/36.+DX*Y(IEND)/2.*(X(IEND)-DX/3.)**2
      RETURN
      END
```

Flowchart of Subroutine INTEG

```
                         ••••••••••••••••••••••••••••••••••••••••••••••••
                         "   SUBROUTINE INTEG(X,Y,XSTART,XEND,          /
                          •  ISTART,IEND,R,R1,R2)                      /
                           "•••••••••••••••••••••••••••••••••••••••••••/
                                               I
                                               I
                         •••••••••••••••••••••••••••••••••••••••••••••••
                         :            DIMENSION X(25),Y(25)            :
                         :                    R=0.                     :
                         :                    R1=0.                    :
                         :                    R2=0.                    :
                         :                    Y1=0.                    :
                         :                 X1=XSTART                   :
                         :•••••••••••••••••••••••••••••••••••••••••••••:
                                               I
                                               I
                         •••••••••••••••••••••••••••••••••••••••••••••••
A----------------------->:            DO 1 I=ISTART,IEND               :
A                        :•••••••••••••••••••••••••••••••••••••••••••••:
A                                              I
A                                              I
A                        •••••••••••••••••••••••••••••••••••••••••••••••
A                        :                 DX=X1-X(I)                  :
A                        :                 DY=Y(I)-Y1                  :
A                        :              R=R+DX*(Y1+DY/2.)              :
A                        : R1=R1+DX*Y1*(X1-DX/2.)+DX*DY/2.*(X1-2.*     :
A                        : DX/3.)                                      :
A                        : R2=R2+DX**3*Y1/12.+DX**3*DY/36.+DX*Y1*(     :
A                        : X1-DX/2.)**2+DX*DY/2.*(X1-2.*DX/3.)**2      :
A                        :                  X1=X(I)                    :
A                        :                  Y1=Y(I)                    :
A                        :•••••••••••••••••••••••••••••••••••••••••••••:
A                                              I
A                          I     1_            I
A                        •••••••••••••••••••••••••••••••••••••••••••••••
-------------------------:                 CONTINUE                    :
                         :•••••••••••••••••••••••••••••••••••••••••••••:
                                               I
                                               I
                         •••••••••••••••••••••••••••••••••••••••••••••••
                         :              DX=X(IEND)-XEND                :
                         :            R=R+DX*Y(IEND)/2.                :
                         : R1=R1+DX*Y(IEND)*(X(IEND)-DX/3.)/2.         :
                         : R2=R2+DX**3*Y(IEND)/36.+DX*Y(IEND)/2.*(X(   :
                         : IEND)-DX/3.)**2                             :
                         :•••••••••••••••••••••••••••••••••••••••••••••:
                                               I
                                               I
                                 /''''''''''''''''''''''"
                                 :       RETURN          :
                                 "•••••••••••••••••••••••/
```

APPENDIX B - DEFINITION OF PROGRAM VARIABLES

The following variables are used in the main program. (Following these are definitions of variables used in the subroutines.)

A	=	an array of section areas
AMAX	=	the maximum section area
AWP	=	the area of the waterplane
AYC	=	an array containing the transverse center of the section areas
AYM	=	an array containing the transverse moments of the sections
AYM1	=	a temporary variable for AYM
AZC	=	an array containing the vertical centers of the station areas
AZM	=	an array containing the vertical moments of the station areas
AZM1	=	a temporary variable for AZM
A1	=	a temporary variable for A
B	=	an array containing the waterplane width of the various sections
BEAM	=	the maximum submerged beam of the boat
BLANK	=	a dummy variable
BML	=	the longitudinal metacentric height above the center of buoyancy
BMT	=	the transverse metacentric height above the center of buoyancy
BWP	=	an array containing the waterplane beam at each station
BWP1	=	a temporary variable for BWP
BYC	=	an array containing the transverse center of the waterplane at each station
BYI	=	an array containing the transverse moment of inertia at each station
BYI1	=	a temporary variable for BYI
BYM	=	an array containing the transverse moment of the waterplane at each station
BYM1	=	a temporary variable for BYM
B1	=	a temporary variable for B
CA1	=	an array containing a coefficient defined as the section area divided by the maximum section area
CA2	=	an array containing a coefficient defined as the section area divided by the area of a rectangle with the same beam and draft
CB	=	the block coefficient based on waterline length, beam and maximum draft
CIL	=	the longitudinal inertia coefficient defined as the longitudinal waterplane inertia divided by the inertia of a rectangle with the same length and beam as the waterplane
CIT	=	the transverse inertia coefficient defined similar to CIL
COSPHI	=	a temporary variable containing the cosine of the angle phi
CP	=	the prismatic coefficient defined as the block coefficient divided by the transverse area coefficient
CVP	=	the vertical prismatic coefficient defined as the block coefficient divided by the waterplane coefficient
CW	=	the waterplane coefficient defined as the waterplane area divided by the area of a rectangle with the same length and beam as the waterplane
CX	=	the transverse area coefficient defined as the maximum section area divided by the area of a rectangle with the same beam and draft as the maximums

DISP = the displacement of the hull in pounds
DPHI = an incremental value of the angle phi
DRAFT = an array containing the draft at each section
DRMAX = the maximum draft
DT = an incremental value of the draft
DTHETA = an incremental value of the angle theta
GIRTH = an array containing the girth of each station
GIRTH1 = a temporary variable for GIRTH
GML = the longitudinal metacentric height above the center of gravity
GMT = the transverse metacentric height above the center of gravity
GZL = the longitudinal righting arm
GZT = the transverse righting arm
I = a counter
IEND = the subscript of the aftermost submerged station
INPUT = a variable defining the device number for input of data cards
IPRINT = a variable defining the device number for the printout
IPTS = a temporary variable for NPTS
ISTA = a counter
ISTART = the subscript of the forwardmost submerged station
ITEST = a variable used in testing for equilibrium
I1 = a counter
I2 = a counter
J = a counter
K = a counter
K1 = a counter
L = a counter
LCB = the longitudinal center of buoyancy
LCBM = the longitudinal moment of buoyancy
LCF = the longitudinal center of flotation
LCFM = the longitudinal moment of the waterplane area
LCG = the longitudinal center of gravity
LCGØ = the input value of the longitudinal center of gravity
LMOM = the longitudinal righting moment
LWL = the waterplane length
LWPI = the longitudinal waterplane inertia
NCASES = the number of cases to be calculated for
NOFFS = the number of offsets to be read in
NP = a temporary variable for NPTS
NPHI = a control code defining whether the heel angle should be allowed to seek equilibrium
NPTS = an array containing the number of points on each station
NS = a variable used in setting up a table for output of the results
NSTA = the number of stations
NS1 = a variable used in setting up a table for the output of results
NT = a control code defining whether the draft should be allowed to seek equilibrium
NTHETA = a control code defining whether the trim angle should be allowed to seek equilibrium
NUMBER = an array containing the alphanumeric station numbers
N1 = a counter
N2 = a counter
N3 = a counter

PHI = the heel angle in radians
PHID = the heel angle in degrees
PHIØ = the input value of heel angle
RHO = the density of the water in pounds per cubic foot
SINPHI = the sine of the heel angle
T = the depth of water relative to the coordinate system
TCB = the transverse center of buoyancy
TCBM = the transverse moment of buoyancy
TCB1 = a temporary value for TCB
TCF = the transverse center of flotation
TCFM = the transverse moment of the waterplane area
TCF1 = a temporary value for TCF
TCG = the transverse center of gravity
TCGØ = the input value of the transverse center of gravity
TCG1 = a temporary value of TCG
THETA = the trim angle in radians
THETAD = the trim angle in degrees
THETAØ = the input value of trim angle
THETA1 = a temporary value of THETA
TITLE = an alphanumeric title which is used in the output
TMOM = the transverse righting moment
TWPI = the transverse waterplane inertia
TØ = the input value of draft relative to the coordinate system
T1 = a temporary value of T
VCB = the vertical center of buoyancy
VCBM = the vertical moment of buoyancy
VCB1 = a temporary value of VCB
VCF1 = the vertical center of flotation in original coordinate system
VCG = the vertical center of gravity
VCGØ = the input value for the vertical center of gravity
VCG1 = a temporary value for the vertical center of gravity
VDISP = the displaced volume
VFORCE = the residual vertical force
VOLUME = the desired displaced volume for equilibrium
WEIGHT = the weight of the boat in pounds
WS = the wetted surface
X = an array containing the longitudinal offsets of the stations
XEND = the longitudinal coordinate of the aftermost point of the waterplane
XSTART = the longitudinal coordinate of the forwardmost point on the waterplane
Y = a two-dimensional array containing the transverse coordinates of the offsets defining the hull form
YØ = a two-dimensional array containing the input values of the transverse coordinates of the hull form
Z = a two-dimensional array containing the vertical coordinates of the offsets defining the hull form
ZHIGH = a temporary value defining the vertical location of the water surface at each station relative to the coordinate system
ZLOW = an array containing the lowest points on each station
ZØ = a two-dimensional array containing the input values of the vertical coordinates defining the hull form

The following variables are used in subroutine SECT. (Variables referenced as subroutine arguments are not included in these definitions; they are the same as in the main program.)

DA	= an incremental value of the area
DAYM	= an incremental value of the transverse moment of area
DAZM	= an incremental value of the vertical moment of area
DGIRTH	= an incremental value of the girth
DY	= the transverse distance from one point to the next
DZ	= the vertical distance from one point to the next
J	= a counter
YAVG	= the average of two transverse offsets
YMAX	= the largest transverse offset encountered
YMIN	= the smallest transverse offset encountered, including negative values
YØ	= a temporary variable for a transverse distance
Y1	= a temporary variable for a transverse offset
Y2	= a temporary variable for a transverse offset
Z1	= a temporary variable for a vertical offset
Z2	= a temporary variable for a vertical offset

The following variables are used in subroutine ENDPT. (Variables referenced as subroutine arguments are not included.)

DY	= an incremental distance
J	= a counter
J1	= a counter
K	= a value defining whether the forward or after end point of the water plane is being investigated

The following variables are used in subroutine INTEG. (Variables referenced as subroutine arguments are not included.)

DX	= an incremental distance in the X direction
DY	= an incremental distance in the Y direction
I	= a counter
X1	= a temporary variable for the X array
Y1	= a temporary variable for the Y array

APPENDIX C – SAMPLE RUN

```
NBS HYDROSTATICS PROGRAM    COAST GUARD R AND D CENTER

HULL FORM DATA USED-
RESEARCH BOAT 75-15   12 FT JONBOAT
         9
  BOW   -1     0     1     2     5     8    10STERN
         3     5.9500
     .0000     1.1300
    1.2400     1.1300
    1.2700     1.2000
         3     5.3400
     .0000      .4300
    1.1300      .4300
    1.3500     1.2850
         3     4.3400
     .0000      .1900
    1.2850      .1900
    1.4800     1.2350
         3     3.3400
     .0000      .0500
    1.3250      .0500
    1.6000     1.1900
         3     2.3400
     .0000      .0300
    1.3250      .0300
    1.6050     1.1600
         3     -.6600
     .0000      .0100
    1.3250      .0100
    1.8650     1.0700
         3    -3.6600
     .0000      .0000
    1.3250      .0000
    1.8500     1.0650
         3    -5.6600
     .0000      .0000
    1.3250      .0000
    1.7150     1.1200
         3    -5.9500
     .0000     1.2100
    1.1700     1.2100
    1.6900     1.1300
NUMBER OF CASES= 4
```

```
RBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

* RESEARCH BOAT 75-15  12 FT JONBOAT                          *

RESULTS BY SECTION       T=   .250 FT.  THETA=   .000 DEG.   PHI=   .000 DEG.   **VALUES IN ORIGINAL COORDINATES**
                              .250               .000               .000        **VALUES IN ROTATED  COORDINATES**
STATION NUMBER            BOW      -1        0        1        2        5        8       10    STERN
X-POSITION       (FT)   5.950   5.340    4.340    3.340    2.340    -.660   -3.660   -5.660   -5.950
AREA          (SQ.FT)    .000    .000     .155     .540     .555     .565     .693     .684     .000
CA1=AREA/MAX.AREA        .000    .000     .223     .778     .853     .960    1.000     .987     .000
CA2=AREA/BEAM/DRAFT      .000    .000     .996     .982     .980     .958     .957     .969     .000
AREA Y-MOMENT(CU.FT)     .000    .000     .000     .000     .000     .000     .000     .000     .000
AREA Y-CENTER    (FT)    .000    .000     .000     .000     .000     .000     .000     .000     .000
AREA Z-MOMENT(CU.FT)     .000    .000     .034     .081     .084     .088     .085     .086     .000
AREA Z-CENTER    (FT)    .000    .000     .220     .151     .141     .132     .127     .126     .000
WP WIDTH         (FT)    .000    .000    2.592    2.746    2.759    2.895    2.896    2.824     .000
WP Y-MOMENT   (SQ.FT)    .000    .000     .000     .000     .000    -.000     .000     .000     .000
WP Y-CENTER      (FT)    .000    .000     .000     .000     .000    -.000     .000     .000     .000
WP Y-INERTIA  (CU.FT)    .000    .000    1.452    1.726    1.750    2.021    2.025    1.877     .000
WP BEAM(OVERALL)(FT)     .000    .000    2.592    2.746    2.759    2.895    2.896    2.824     .000
DRAFT            (FT)   -.880   -.180     .060     .200     .220     .240     .250     .250    -.880
GIRTH            (FT)    .000    .000    2.692    3.061    3.103    3.159    3.207    3.179     .000

DATA USED-
  464.000   -1.520    .000   1.510    .250    .000    .000   62.400  1 1 1
```

RBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

```
*****************************************************************************
*                                                                           *
* RESEARCH BOAT 75-15   12 FT JONBOAT                                       *
*                                                                           *
*****************************************************************************
*T      (        .250)       .250 FT   *DISPLACEMENT           390.746 LB    *
*THETA  (        .000)       .000 DEG  *VOLUME DISP.             6.262 CU.FT *
*PHI    (        .000)      0.000 DEG  *LCB                     -1.028 FT    *
*WEIGHT                   464.000 LB   *TCB     (        .000)     .000 FT    *
*LCG                      -1.520 FT   *VCB     (        .134)     .134 FT    *
*TCG    (        .000)       .000 FT   *WATERPLANE AREA         28.724 SQ.FT *
*VCG    (       1.510)      1.510 FT   *LCF                      -.675 FT    *
*                                      *TCF     (      -.000)    -.000 FT    *
*                                      *VCF     (        .250)     .250 FT    *
*                                      *                                     *
*****************************************************************************
*WATERPLANE LENGTH         10.314 FT   *LONG.MOMENT           -192.370 FT.LB *
*WATERPLANE BEAM            2.896 FT   *LONG.GZ                  -.492 FT    *
*MAXIMUM DRAFT               .250  FT  *                                     *
*MAX.SECTION AREA            .693 SQ.FT*TRANS.MOMENT              .000 FT.LB *
*FWD WATERPLANE END         4.590 FT   *TRANS.GZ                  .000 FT    *
*AFT WATERPLANE END        -5.724 FT   *                                     *
*WETTED SURFACE            31.817 SQ.FT*VERTICAL FORCE          -73.254 LB    *
*                                      *                                     *
*                                      *                                     *
*****************************************************************************
*LONG.INERTIA             243.202 FT4  *BLOCK COEFFICIENT        .83643      *
*BML                       38.83[illegible] FT   *MAX.SECTION COEF         .95745      *
*GML                       37.463 FT   *PRISMATIC COEF           .87569      *
*                                      *WATERPLANE COEF.         .96149      *
*TRANS.INERTIA             19.197 FT4  *VERT.PRISMATIC COEF      .37201      *
*BMT                        3.066 FT   *LONG.INERTIA COEF        .07652      *
*GMT                        1.690 FT   *TRANS.INERTIA COEF       .07659      *
*                                      *                                     *
*                                      *                                     *
*****************************************************************************
* VALUES IN PARENTHESIS ARE IN NON-ROTATED ORIGINAL COORDINATES             *
*****************************************************************************
```

RdS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

* RESEARCH BOAT 75-15   12 FT JONBOAT   *

RESULTS BY SECTION   T= .206 FT. THETA= .000 DEG. PHI= 20.000 DEG. **VALUES IN ORIGINAL COORDINATES**
.194 .000 .000 **VALUES IN ROTATED COORDINATES**

STATION NUMBER	BOW	-1	0	1	2	5	8	10	STERN
X-POSITION (FT)	5.950	5.340	4.340	3.340	2.340	-.660	-3.660	-5.660	-5.950
AREA (SQ.FT)	.000	.053	.345	.614	.655	.777	.794	.746	.000
CA1=AREA/MAX.AREA	.000	.067	.435	.774	.825	.978	1.000	.940	.000
CA2=AREA/BEAM/DRAFT	.000	.500	.500	.500	.500	.500	.500	.500	.000
AREA Y-MOMENT(CU.FT)	.000	-.058	-.326	-.519	-.542	-.693	-.697	-.613	.000
AREA Y-CENTER (FT)	.000	-1.088	-.945	-.845	-.827	-.892	-.878	-.828	.000
AREA Z-MOMENT(CU.FT)	.000	.007	.015	-.004	-.008	-.014	-.017	-.016	.000
AREA Z-CENTER (FT)	.000	.135	.042	-.006	-.012	-.019	-.022	-.022	.000
WP WIDTH (FT)	.000	.605	1.518	2.047	2.117	2.436	2.454	2.306	.000
WP Y-MOMENT (SQ.FT)	.000	-.622	-1.187	-1.304	-1.298	-1.740	-1.703	-1.430	.000
WP Y-CENTER (FT)	.000	-1.027	-.782	-.637	-.613	-.714	-.694	-.620	.000
WP Y-INERTIA (CU.FT)	.000	.657	1.220	1.545	1.586	2.447	2.413	1.908	.000
WP BEAM(OVERALL)(FT)	.000	.605	1.518	2.047	2.117	2.436	2.454	2.306	.000
DRAFT (FT)	-.444	.176	.455	.600	.619	.638	.647	.647	-.290
GIRTH (FT)	.000	.729	1.859	2.475	2.555	2.799	2.828	2.727	.000

DATA USED-
464.000   -1.520   .000   1.510   .250   .000   20.000   62.400   0 1 1

PBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

```
***************************************************************************
*                                                                         *
* RESEARCH BOAT 75-15  12 FT JONBOAT                                      *
*                                                                         *
***************************************************************************
*T      (        .206)      .194 FT   *DISPLACEMENT            463.992 LB     *
*THETA  (        .000)      .000 DEG  *VOLUME DISP.              7.436 CU.FT  *
*PHI    (      20.000)     0.000 DEG  *LCB                       -.860 FT     *
*WEIGHT                  464.000 LB   *TCB     (      -.822)     -.869 FT     *
*LCG                      -1.520 FT   *VCB     (       .284)     -.014 FT     *
*TCG    (        .000)     -.516 FT   *WATERPLANE AREA          24.131 SQ.FT  *
*VCG    (       1.510)     1.419 FT   *LCF                       -.653 FT     *
*                                     *TCF     (      -.576)     -.684 FT     *
*                                     *VCF     (       .416)      .194 FT     *
*                                     *                                       *
***************************************************************************
*WATERPLANE LENGTH        11.374 FT   *LONG.MOMENT            -306.421 FT.LB  *
*WATERPLANE BEAM           2.454 FT   *LONG.GZ                   -.660 FT     *
*MAXIMUM DRAFT              .647  FT  *                                       *
*MAX.SECTION AREA           .794 SQ.FT*TRANS.MOMENT           -163.743 FT.LB  *
*FWD WATERPLANE END        5.513 FT   *TRANS.GZ                  -.353 FT     *
*AFT WATERPLANE END       -5.860 FT   *                                       *
*WETTED SURFACE           28.338 SQ.FT*VERTICAL FORCE            -.00[illegible] LB     *
*                                     *                                       *
*                                     *                                       *
***************************************************************************
*LONG.INERTIA            219.856 FT4  *BLOCK COEFFICIENT         .41178       *
*BML                      29.567 FT   *MAX.SECTION COEF          .50000       *
*GML                      28.134 FT   *PRISMATIC COEF            .82356       *
*                                     *WATERPLANE COEF.          .86472       *
*TRANS.INERTIA            10.511 FT4  *VERT.PRISMATIC COEF       .47620       *
*BMT                       1.414 FT   *LONG.INERTIA COEF         .06090       *
*GMT                       -.020 FT   *TRANS.INERTIA COEF        .06257       *
*                                     *                                       *
*                                     *                                       *
***************************************************************************
* VALUES IN PARENTHESIS ARE IN NON-ROTATED ORIGINAL COORDINATES           *
***************************************************************************
```

RBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

* RESEARCH BOAT 75-15 12 FT JONBOAT   *

RESULTS BY SECTION   T= .182 FT.   THETA= -1.483 DEG.   PHI= 20.000 DEG.   **VALUES IN ORIGINAL COORDINATES**
.171   -1.394   .000   **VALUES IN ROTATED COORDINATES**

STATION NUMBER	BOW	-1	0	1	2	5	8	10	STERN
X-POSITION (FT)	5.950	5.340	4.340	3.340	2.340	-.660	-3.660	-5.660	-5.950
AREA (SQ.FT)	.000	.001	.172	.420	.497	.761	.965	1.035	.000
CA1=AREA/MAX.AREA	.000	.001	.172	.406	.481	.735	.933	1.000	.000
CA2=AREA/BEAM/DRAFT	.000	.500	.500	.500	.500	.500	.500	.500	.000
AREA Y-MOMENT(CU.FT)	.000	-.001	-.185	-.365	-.439	-.682	-.811	-.781	.000
AREA Y-CENTER (FT)	.000	-1.193	-1.038	-.917	-.882	-.896	-.840	-.754	.000
AREA Z-MOMENT(CU.FT)	.000	.000	-.008	-.032	-.033	-.017	.022	.057	.000
AREA Z-CENTER (FT)	.000	.033	-.043	-.075	-.065	-.023	.023	.055	.000
WP WIDTH (FT)	.000	.082	1.091	1.693	1.845	2.411	2.706	2.716	.000
WP Y-MOMENT (SQ.FT)	.000	-.097	-1.004	-1.261	-1.283	-1.735	-1.725	-1.382	.000
WP Y-CENTER (FT)	.000	-1.184	-.920	-.745	-.696	-.720	-.637	-.509	.000
WP Y-INERTIA (CU.FT)	.000	.115	1.032	1.344	1.416	2.417	2.750	2.372	.000
WP BEAM(OVERALL)(FT)	.000	.082	1.091	1.693	1.845	2.411	2.706	2.716	.000
DRAFT (FT)	-.611	.024	.327	.496	.539	.631	.714	.762	-.168
GIRTH (FT)	.000	.099	1.335	2.047	2.227	2.771	3.118	3.212	.000

DATA USED-
464.000   -1.520   .000   1.510   .250   .000   20.000   62.400   0 0 1

RBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

```
***********************************************************************
*                                                                     *
* RESEARCH BOAT 75-15   12 FT JONBOAT                                 *
*                                                                     *
***********************************************************************
*T     (        .182)      .171 FT   *DISPLACEMENT          464.718 LB    *
*THETA (      -1.483)    -1.394 DEG  *VOLUME DISP.            7.447 CU.FT *
*PHI   (      20.000)     0.000 DEG  *LCB                    -1.553 FT    *
*WEIGHT                 464.000 LB   *TCB    (      -.809)    -.859 FT    *
*LCG                    -1.520 FT   *VCB    (       .289)    -.005 FT    *
*TCG   (        .000)    -.516 FT    *WATERPLANE AREA        23.550 SQ.FT *
*VCG   (       1.510)    1.419 FT    *LCF                    -1.101 FT    *
*                                    *TCF    (      -.578)    -.677 FT    *
*                                    *VCF    (       .393)     .171 FT    *
*                                    *                                    *
***********************************************************************
*WATERPLANE LENGTH      11.261 FT    *LONG.MOMENT             -.819 FT.LB *
*WATERPLANE BEAM         2.716 FT    *LONG.GZ                 -.002 FT    *
*MAXIMUM DRAFT            .762  FT   *                                    *
*MAX.SECTION AREA        1.035 SQ.FT*TRANS.MOMENT         -159.007 FT.LB *
*FWD WATERPLANE END      5.363 FT    *TRANS.GZ                -.342 FT    *
*AFT WATERPLANE END     -5.898 FT    *                                    *
*WETTED SURFACE         27.587 SQ.FT*VERTICAL FORCE            .718 LB    *
*                                    *                                    *
*                                    *                                    *
***********************************************************************
*LONG.INERTIA          200.358 FT4   *BLOCK COEFFICIENT        .31951     *
*BML                    26.903 FT    *MAX.SECTION COEF         .50000     *
*GML                    25.479 FT    *PRISMATIC COEF           .63901     *
*                                    *WATERPLANE COEF.         .77007     *
*TRANS.INERTIA          11.250 FT4   *VERT.PRISMATIC COEF      .41490     *
*BMT                     1.511 FT    *LONG.INERTIA COEF        .05167     *
*GMT                      .086 FT    *TRANS.INERTIA COEF       .04988     *
*                                    *                                    *
*                                    *                                    *
***********************************************************************
* VALUES IN PARENTHESIS ARE IN NON-ROTATED ORIGINAL COORDINATES       *
***********************************************************************
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RBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

* RESEARCH BOAT 75-15 12 FT JONBOAT *

RESULTS BY SECTION   T= .244 FT.   THETA= -1.195 DEG.   PHI=-13.244 DEG.   **VALUES IN ORIGINAL COORDINATES**

.238   -1.163   .000   **VALUES IN ROTATED COORDINATES**

STATION NUMBER	BOW	-1	0	1	2	5	8	10	STERN
X-POSITION (FT)	5.950	5.340	4.340	3.340	2.340	-.660	-3.660	-5.660	-5.950
AREA (SQ.FT)	.000	.000	.157	.429	.514	.756	.961	1.046	.000
CA1=AREA/MAX.AREA	.000	.000	.150	.410	.491	.723	.918	1.000	.000
CA2=AREA/BEAM/DRAFT	.000	.000	.500	.500	.500	.500	.505	.531	.000
AREA Y-MOMENT(CU.FT)	.000	.000	.152	.331	.369	.510	.564	.532	.000
AREA Y-CENTER (FT)	.000	.000	.966	.771	.718	.674	.587	.508	.000
AREA Z-MOMENT(CU.FT)	.000	.000	.010	.012	.018	.053	.103	.139	.000
AREA Z-CENTER (FT)	.000	.000	.063	.028	.035	.069	.107	.133	.000
WP WIDTH (FT)	.000	.000	1.215	2.019	2.212	2.776	3.089	3.002	.000
WP Y-MOMENT (SQ.FT)	.000	.000	.973	1.022	.949	1.013	.780	.618	.000
WP Y-CENTER (FT)	.000	.000	.801	.506	.429	.365	.253	.206	.000
WP Y-INERTIA (CU.FT)	.000	.000	.929	1.204	1.309	2.153	2.652	2.381	.000
WP BEAM(OVERALL)(FT)	.000	.000	1.215	2.019	2.212	2.776	3.089	3.002	.000
DRAFT (FT)	-.699	-.030	.259	.425	.465	.545	.616	.656	-.354
GIRTH (FT)	.000	.000	1.414	2.330	2.550	3.092	3.456	3.477	.000

DATA USED-

464.000   -1.520   .300   1.510   .250   .000   .030   62.400   0 0 0

NBS HYDROSTATICS PROGRAM   COAST GUARD R AND D CENTER

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********************************************************************************
*                                                                              *
* RESEARCH BOAT 75-15   12 FT JONBOAT                                          *
*                                                                              *
********************************************************************************
*T      (       .244)     .238 FT   *DISPLACEMENT              463.107 LB     *
*THETA (     -1.195)    -1.163 DEG  *VOLUME DISP.                7.422 CU.FT  *
*PHI    (   -13.244)     0.000 DEG  *LCB                        -1.547 FT     *
*WEIGHT                 464.000 LB  *TCB     (       .602)        .638 FT     *
*LCG                    -1.520 FT   *VCB     (       .229)        .084 FT     *
*TCG    (       .300)     .638 FT   *WATERPLANE AREA            26.929 SQ.FT  *
*VCG    (      1.510)    1.401 FT   *LCF                        -1.065 FT     *
*                                   *TCF     (       .289)        .353 FT     *
*                                   *VCF     (       .312)        .238 FT     *
*                                   *                                         *
********************************************************************************
*WATERPLANE LENGTH      11.083 FT   *LONG.MOMENT                  .298 FT.LB  *
*WATERPLANE BEAM         3.089 FT   *LONG.GZ                      .001 FT     *
*MAXIMUM DRAFT            .656  FT  *                                         *
*MAX.SECTION AREA        1.046 SQ.FT*TRANS.MOMENT                 .019 FT.LB  *
*FWD WATERPLANE END      5.235 FT   *TRANS.GZ                     .000 FT     *
*AFT WATERPLANE END     -5.648 FT   *                                         *
*WETTED SURFACE         30.490 SQ.FT*VERTICAL FORCE              -.893 LB     *
*                                   *                                         *
*                                   *                                         *
********************************************************************************
*LONG.INERTIA          223.677 FT4  *BLOCK COEFFICIENT         .33043         *
*BML                    30.166 FT   *MAX.SECTION COEF          .51636         *
*GML                    28.849 FT   *PRISMATIC COEF            .63992         *
*                                   *WATERPLANE COEF.          .78667         *
*TRANS.INERTIA          17.040 FT4  *VERT.PRISMATIC COEF       .42004         *
*BMT                     2.296 FT   *LONG.INERTIA COEF         .05324         *
*GMT                      .979 FT   *TRANS.INERTIA COEF        .05218         *
*                                   *                                         *
*                                   *                                         *
********************************************************************************
* VALUES IN PARENTHESIS ARE IN NON-ROTATED ORIGINAL COORDINATES               *
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APPENDIX D - TEST RESULTS

One of several tests conducted for program verification is presented here. This test consisted of loading a jonboat to the load specified in the fourth sample case of Appendix C, and measuring the resulting draft, trim, and heel. Trim and heel angles were determined based on freeboard measurements.=

	BOAT TEST	COMPUTER RUNS
Draft (feet amidships)	0.242	0.244
Trim (degrees)	-1.52°	-1.195°
Heel (degrees)	12.45°	13.244°